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The Leardo Map of the World of 1452 or 1453. Colored reproduction (measuring 28⅝ x 23½ inches, printed on sheet 35 x 30 inches) of map in the collections of the American Geographical Society. Accompanied by volume containing text by JOHN KIRTLAND WRIGHT describing the original map and a note by A. B. HOEN on the method of reproduction, with 3 photographs and 7 maps, viii and 90 pp. *Library Series No. 4.* 1927. $15.00 ($2.00 for text alone).

Separate Maps published in the *Geographical Review* and the *Bulletin of the American Geographical Society*, the majority in color. 25 cents each. A list will be sent upon request.

THE
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AN ARCHEOLOGICAL RECONNAISSANCE BY AIR IN CENTRAL AMERICA

Oliver Ricketson, Jr., and A. V. Kidder

Carnegie Institution of Washington

With photographs by Mrs. Lindbergh and Oliver Ricketson, Jr.

UNDER the leadership of Colonel Charles A. Lindbergh, Pan American Airways, Inc., and the Carnegie Institution of Washington undertook in early October, 1929, exploratory flights over certain portions of the Maya area in British Honduras, Guatemala, and southern Mexico.

The Maya Indian civilization, in many ways the most brilliant pre-Columbian cultural development of the New World, arose during the first millennium before the Christian era from origins as yet not surely identified. The earliest known Maya settlements are found in what is now the Department of Petén in northern Guatemala; and that region apparently forms the center from which the Maya carried their city-building activities into adjacent territory in British Honduras, Honduras, and Yucatan. The classic period of Maya history, the Old Empire as it has been called by Dr. S. G. Morley, opened at about the time of Christ and lasted until 610 A. D. (according to the Morley-Spinden correlation of Maya and Christian chronology). The beginning of the seventh century saw the complete break-up of the Old Empire, the abandonment of its cities, and the migration of the people into new lands, among which northern Yucatan was destined to become the most important. In that country, after periods of colonization and cultural transition terminating in 985 A. D., there took place during the eleventh and twelfth centuries an extraordinary renaissance, marked by the building of such great cities as Uxmal and Chichén Itzá. Intercity feuds culminated about the year 1200 in the importation of Nahua mercenaries and in a

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strong Mexicanization of Maya art and religion, thus opening the Toltec period, a time of vigorous growth and intense building activity (1201–1458). This was followed by a century of decline immediately preceding the Spanish Conquest, when the native civilization was abruptly snuffed out.

As is indicated by the above brief summary, we already know more of the pre-Columbian history of the Maya than of any other group of aboriginal Americans. And when it is taken into consideration that they were also outstanding as architects, astronomers, mathematicians, and artists, and were in possession of a written language, it can easily be understood that intensive study of the Maya is the most important task of American archeology. Research upon the Maya is, however, rendered exceedingly difficult by the dense tropical jungle which now covers most of the country formerly occupied by them and which is heaviest and most impenetrable in the region where the oldest cities are found. Access, indeed, to the Petén area can only be had by using the bad, indirect, and often overgrown trails cut through the forest by the *chicleros*, bleeders of the chicle sapote tree, from the sap of which chewing gum is made. The chicle trails, moreover, although they are gradually being extended from British Honduras, Guatemala, and Mexico, have not yet met, so that a large and entirely unknown region still exists between their present terminations.

Slow and laborious travel, a hot, humid climate, swarms of insects, and prevalence of tropical diseases have greatly retarded exploration of the Maya country. Even in such parts of it as can be reached the traveler is so buried in the "bush," so shut in and engulfed by the mere weight of vegetation that he can literally never see more than a few feet or yards and so is almost totally in the dark as to the topography of the regions he is examining. A rise of ground crossed by the trail may, for example, be an isolated hill or part of an extensive ridge; it may be the highest land in the vicinity or a saddle in an important divide. It is almost always impossible to reach any point for extended views over the terrain. For this reason no proper knowledge has been gained of the lay of the mountains, hills, plains, swamps, and drainages; of their position, their interrelation, and the nature of their forest cover. Without detailed information as to such vitally significant environmental factors it is manifestly impossible to gain a true understanding of the people whose history they must have played so large a part in molding. To determine whether the airplane could serve to obviate some of the above hindrances, and to gauge its usefulness as an adjunct to other phases of scientific exploration, Colonel Lindbergh undertook the flights chronicled in the present paper.

Colonel Lindbergh's interest in the Maya field was aroused during

FIG. 1—Sketch map of British Honduras and contiguous parts of Guatemala and Mexico, showing the courses of the archeological flights. Regarding the position of the lakes here shown east of Chichan Hanab see footnote 7. The roman numerals have reference to the ruins sighted on the flight of October 9. Scale approximately 1 : 5,000,000.

February, 1929, when, in company with Mr. John Hambleton, he was flying from Belize, British Honduras, to Havana. His course carried him along the east coast of Yucatan, and he took opportunity to detour inland, where he observed, protruding from the dense forest cover, a group of mounds upon the summit of one of which there could be seen the ruins of a masonry structure. On his return to

Washington he communicated with Secretary Abbot of the Smithsonian Institution, who put him in touch with President J. C. Merriam of the Carnegie Institution. Dr. Merriam suggested the examination from the air of certain parts of the Pueblo region in Arizona and New Mexico; and during the month of August, 1929, Colonel Lindbergh used the camp of A. V. Kidder at the Phillips Academy excavations at Pecos, N. Mex., as a base from which a number of flights were made over the cliff-dwelling country.

Planning the Flights

The results in photographs of known sites, in discovery of new ruins, and in topographical data were so striking, that Colonel Lindbergh and Dr. Kidder felt that an attempt should be made to do similar work in Central America. Opportunity to realize the plan was provided by Pan American Airways, Inc., that company through its transportation manager, Mr. James Eaton, placing at the disposal of Colonel Lindbergh and the Carnegie Institution one of their splendid twin-motor Sikorsky amphibions (Fig. 2), supplemented by every facility of their elaborate ground and communication services. The flights were to be made from Belize at the conclusion of Colonel and Mrs. Lindbergh's September tour of the Caribbean.

By October 5 the exploring party had assembled in Belize,[1] and three major areas had been selected for reconnaissance surveys: the region north of Uaxactun, Guatemala; the country lying within seventy-five miles of the east coast of Yucatan and north of Lake Bacalar in Quintana Roo, Mexico; and the region southeast from Lake Petén, Guatemala, and southwest of the Cockscomb Mountains, British Honduras. A large part of this territory was unexplored, and it was believed that it would be of outstanding interest, both geographically and archeologically. The flight schedules had also been tentatively decided on. Mr. Ricketson acted as observer on October 5 and 6; both the writers took part in the flight of October 7; and Dr. Kidder was observer on October 8 and 9.

Flight of October 6, Belize to Merida

The first flight was made on October 6. The plane left the ramp in front of Newtown Barracks, Belize, at 9.18 a. m., the course being set straight for El Cayo. On the south the terrain showed rough conical hills, gradually rising to their maximum height in the Cockscomb Mountains, while still farther south the whole land mass rose until it was obscured by clouds. On the north nothing was

[1] In Belize Colonel and Mrs. Lindbergh were guests of the Governor, Sir John Burdon, who was greatly interested in the work, and Mr. Ricketson and Dr. Kidder of Mr. Clarence Harvey and the Misses Shufeldt at the home of Mr. P. W. Shufeldt.

visible except a vast jungle-covered plain. The general altitude of the airplane was 500 feet (unless otherwise noted), and the speed was practically always between 85 and 90 miles an hour. Below was the low, swampy growth, locally known as "pine ridge," though the land is neither high nor ridgy. About 27 miles from Belize there was apparent less savana and more trees growing over water-flooded areas, and no savana land was visible ahead. At this point very low,

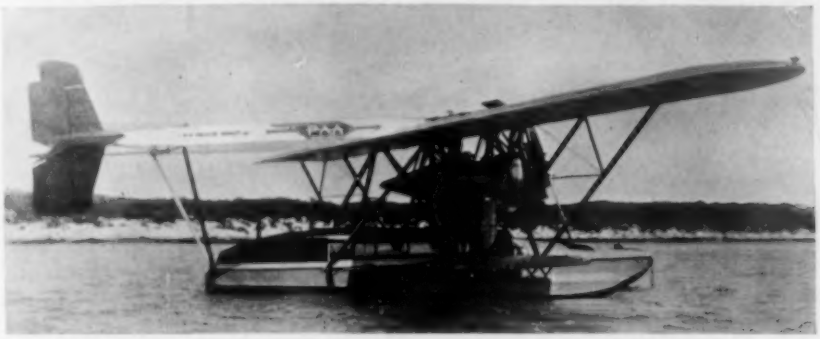

FIG. 2—Twin-motor Sikorsky amphibion, provided by Pan American Airways, Inc., for the flights. Standard Pan-American equipment carried by the expedition included: 1 rubber inflatable boat, oars, and pump; 1 sea anchor; 1 anchor and warp; 1 Very pistol; 1 box rockets.

Additional equipment carried included: 2 hammocks and mosquito bars; 2 blankets; 2 machetes; 1 shotgun and 50 No. 4 shot cartridges; 3 U. S. Army canteens; 1 thermos water jar; 2 pocket compasses; 1 bottle of iodine; 50 quinine tablets; 1 "Optimus" gasoline burner; 3 lbs. rice; 3 boxes raisins; 1 package salt; 12 cans assorted meats; 6 cans assorted vegetables; 12 cakes eating chocolate; 4 boxes assorted biscuit; 2 bottles malted milk; 1 tin cooking chocolate; 3 dozen bananas; 1 sealed tin matches; 2 electric torches; 2 revolvers; 1 Ica camera, 9 x 12 cms; 1 Graflex camera.

The maps carried included: Guatemala (Urrutia, 1924); British Honduras (Lassen, 1911); 3 small-scale maps of Campeche, Yucatan, and Quintana Roo, Mexico; U. S. Government chart, Yucatan region; P. W. Shufeldt Co. MS. map of Petén region; Blom-Ricketson MS. map revised to 1929.

rolling hills appeared to the south. The height and density of the jungle increased perceptibly. At 10.05 a. m., 47 minutes after leaving Belize (66.7 miles), the plane passed over El Cayo,[2] the head of navigation on the Belize River. From El Cayo a course was followed along the eastern branch of the river, the terrain becoming very rough and the river running in a deep gorge with limestone cliffs visible along the sides. The altimeter read 1500 feet.

At 10.15, seven miles from El Cayo, the plane passed over a small, three-legged, palm-thatched structure in a cleared place on the top of a steep hill west of the river, probably an Indian shrine (Fig. 3). The river was full of rapids. At 10.22 we passed a long "slide," which Mr. Ricketson assumed to be Vaca Falls. Calculation, however, shows that the plane was 16 miles from El Cayo, whereas Vaca Falls is only 8 miles from that point and Chequi Bull 15 miles; but this discrepancy may be due to the fact that the plane had followed the winding course of the river and had circled the Indian shrine to

[2] The distance measured on Lassen's 1911 map of British Honduras is 62 miles.

FIG. 3—The structure in the clearing is probably an Indian shrine. Near Vaca Falls, British Honduras.

photograph it. We shortly thereafter crossed over the town of Benque Viejo on the Mopan, the western branch of the Belize River; and three minutes later both the lakes of Yaxha were in sight. We were then flying at 1500 feet. The El Cayo-Flores road was plainly visible, and we circled once over a small clearing on this road called Gabelan. From Benque Viejo to Yaxha settlement took about ten minutes, or 14.2 miles (13 miles on Urrutia's map). Although we then circled for seven minutes in this region, it was not possible to distinguish the Yaxha ruins. Visibility was poor, as there was little or no sunshine. Two lakes were seen beyond the western Yaxha lakes; these are shown in dotted outline and unnamed on Urrutia's map; and a third smaller lake, not shown on the map, was observable just to the northwest.

At 10.40 the plane headed north from Yaxha for Tikal, greatest of the ancient cities of Petén, its tower-like temples being seen from a distance of twenty miles. We left Tikal, after circling and photographing the ruins (Fig. 4), at 10.54, about ten minutes, or 14.2 miles, from Yaxha (Urrutia shows it as 13 miles); and at 11 a. m. the plane passed over the Carnegie Institution's excavations in Group E, Uaxactun, covering in six minutes ground that requires a day's ride to accomplish with pack mules. The trip from El Cayo, here made in less than one hour, usually takes three or four days on the ground (muleback).[3] Photographs were taken of both Group E and the field camp (Figs. 5, 6, 9). At 11.06 the plane headed north.

It is noteworthy that from this point on very little could be seen except the vast expanse of jungle (Fig. 7). A line of rather abrupt but low hills running northeast bounded the great level plain, upon the western edge of which Uaxactun is situated. Four minutes after we left Uaxactun (5.7 miles) a small but well defined valley was

[3] Oliver Ricketson, Jr.: Astronomical Observatories in the Maya Area, *Geogr. Rev.*, Vol. 18, 1928, pp. 215–225.

crossed; this valley ran northwest and southeast into the Uaxactun plain, cutting through the hills at right angles to their general course. The altimeter registered 2000 feet. On the western horizon there could be seen one long low hill and just to the north of it six low abrupt hills. On the eastern horizon the hills bearing northeasterly were trending farther and farther from our course. At 11.22 a. m. (22.7 miles north of Uaxactun) the country on the west appeared even flatter than before, while low hills on the eastern horizon were still visible. *Bajos*, or logwood swamps, whose low tangled vegetation renders them so terrible an obstacle to ground travel, occurred frequently and were both extensive and distinctly marked off from the high bush.

FIG. 4—Temple at Tikal, Guatemala, standing clear above the forest cover.

Forty-two and a half miles north of Uaxactun the eastern hills began to fade out beyond the horizon. At this point the course was changed to the east that we might examine a small conical hill believed by Mr. Ricketson to be surely artificial. No remains of masonry could, however, be made out through the jungle. One minute later the northward course was resumed. From this point on, the country, though flat, was relieved by irregular, bumpy little hills without any particular relation to one another. At 56.8 miles the plane passed over and circled what was obviously a Maya ruin, consisting of two temples facing each other on an artificially raised plaza terrace. It was possible to make out the stone construction in the rear wall of the southernmost temple. What the actual extent of this ruin may be it is impossible to state, but it may be inferred that it is large, for small ones, which must be present in this region, were not visible during the flight. This ruin may be that called Yeso[4] which is shown on the Blom-Ricketson map as about 57 miles north and slightly east of Uaxactun, but it seems more probable that it is Rio Bec, a

[4] Karl Sapper: Sobre la geografía física y la geología de la peninsula de Yucatán, *Bol. Com. Geol. de Mexico*, No. 3, Mexico, 1896.

Fig. 5.—Excavated pyramid at Group E, Uaxactun, from the air.

FIG. 5—Excavated pyramid at Group E, Uaxactun, from the air.

FIG. 6—Ground photograph of pyramid seen in Figure 5.

site discovered by R. E. Merwin of the Peabody Museum. Map locations in this practically unknown region are to be regarded as subject to great error.

From this point nothing but solid jungle was seen until 11.55, or 69.6 miles north of Uaxactun, when the plane passed over a small

FIG. 7—The great plain north of Uaxactun. Note cloud shadows on jungle.

milpa (Indian cornfield cleared in the forest) with no house visible. Four miles beyond, the gentle undulations in the land became more abrupt. It was also noticeable that the jungle appeared somewhat less vividly green than farther south, becoming rather gray in tone. This might well be the effect of decreased rainfall—a phenomenon, well recognized by meteorologists, which occurs as one proceeds northward from the base of the peninsula of Yucatan to its tip.[5] At 12.04 p. m., 82.4 miles north of Uaxactun, we were over a large *bajo* covered with low bush, beneath which yellow water and mud were visible. In the plain to the south there was less distinction between *bajo* and jungle, but here the contrast was very sharp. This no doubt meant better organized drainage.

At 12.08 p. m., 88 miles north of Uaxactun, we crossed a very large milpa, an *aguada* or water hole, and several bush huts. It was thought at the time that this might be Aguada Concepción on the Campeche map. It might also have been Aguada Carolina, which appears in this vicinity in the Blom-Ricketson map but is there shown as a lake. There are several other "lakes" noted on various maps of this section of the country, and presumably all are really

[5] Cf. the rainfall map of Central America (1 : 9,500,000) by H. J. Spinden, *Geogr. Rev.*, Vol. 18, 1928, facing p. 660.

small *aguadas*, as after leaving the Yaxha lakes in Petén we had not sighted a single river, lake, or pond; the only water visible was that in *bajos*. Ten miles farther on the plane flew over a chicle camp. In this region the definition of the drainage was much sharper, trending generally from northwest and west to southeast and east.

FIG. 8—Milpas, or Indian cornfields, 125 miles north of Uaxactun.

Fourteen miles farther on, or approximately 112 miles north of Uaxactun, we passed over a small town with a Spanish church, but it was not possible for us to identify it. The only town in this vicinity, Xkanha, is mapped as being about 17 miles farther north. Milpas and clearings were now extensive, and the low second growth of old milpas was clearly distinguishable from jungle (Fig. 8). At about 125 miles from Uaxactun we passed a stream, the first noted, running from northwest to southeast. Just before this a small Maya pyramid was sighted on a cleared piece of ground. From here on, the horizon appeared absolutely unbroken and level; small streams of black water and green-scummed *aguadas* were occasionally noted.

At 1.00 p. m., or 162 miles from Uaxactun, Colonel Lindbergh bore east to a white tower. There were milpas and huts on all sides. Three minutes later, about five miles beyond, the notebook entry reads: "White buildings on left, 15 miles; and on the right (south) very near us; a large church ahead. Village on right has three 'factory chimneys.' The terrain is absolutely flat; a very definite escarpment runs N. W. and S. E. in an almost exactly straight line." The towns noted above were probably Tekax, Peto, and Saban, respectively, in the state of Yucatan.

FIG. 9

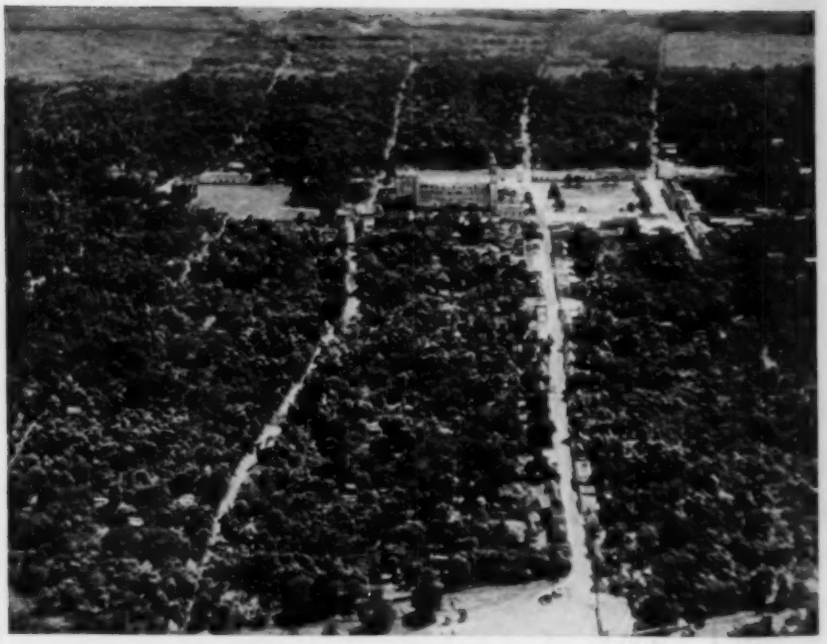

FIG. 10

FIG. 9—Camp of Carnegie Institution at Uaxactun. Mounds of Group A in foreground showing appearance of Maya ruins after clearing of jungle but before excavation.
FIG. 10—Town in state of Yucatan (Peto?).

FIG. 11

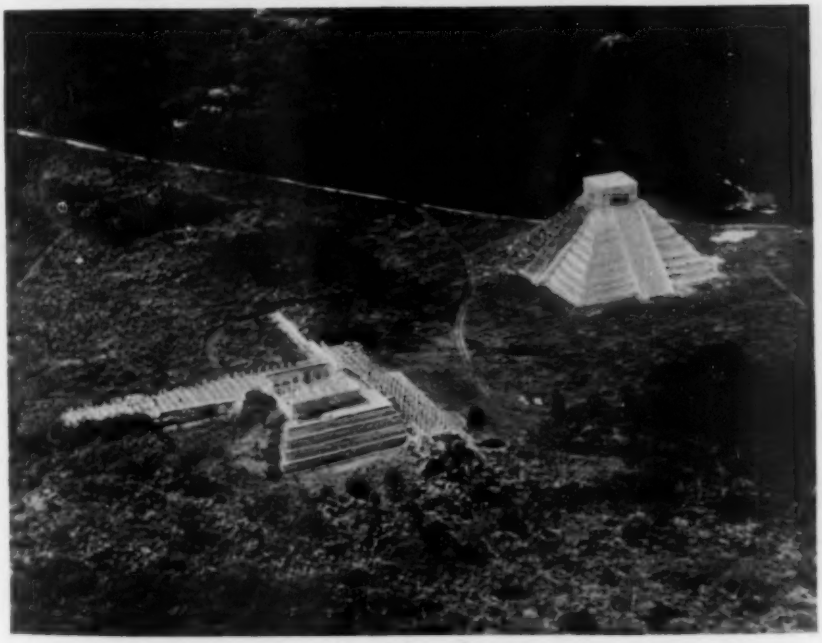

FIG. 12

FIG. 11—General view of the ruins of Chichén Itzá looking north.
FIG. 12—Temple of the Warriors and the Castillo at Chichén Itzá.

At 1.24 p. m., or about 196 miles from Uaxactun, a small Maya temple was sighted in a clearing. Part of the vault of the roof remained, and the walls appeared fairly intact.[6] At 2.02, or 54 miles farther on, the first henequen field was noted. At 2.10, or 11.4 miles farther, Temax was reached. Five more minutes and the Gulf of Mexico was in sight; another five minutes and we were over Motul.

FIG. 13—Lake Payegua, Quintana Roo, where a landing was made.

We landed at Merida at 2.39, or 5 hours and 21 minutes from Belize, a total of 454.8 miles at an estimated rate of 85 miles per hour. An enthusiastic reception was accorded Colonel Lindbergh, and the party was entertained by Governor Torre Diaz.

FLIGHT OF OCTOBER 7, MERIDA TO BELIZE

On the following morning the plane took off at 9.35 a. m., and the course was laid for Chichén Itzá where several circles were made over the ruins and excavations (Figs. 11 and 12). From there the flight was continued south towards the ruins of Yaxuna, which lie about ten miles south of Chichén Itzá, but they could not be seen. From Yaxuna the course was slightly west of south, and at 11.05 the plane was over a series of long, narrow lakes (Fig. 13). These lay, according to Colonel Lindbergh's reckoning, about due east of the mapped position of a large long lake named Chichan Hanab; but whether or not they were Chichan Hanab is not certain.[7] The clear blue water, as well as the strung-out formation of these lakes, gave them the appearance of being the remnant of a previous river system. In all, seven bodies of water were visible, the longest axis of which was north

[6] Tixualahtun? M. de Larenaudière: Mexique et Guatemala, Paris, 1843, p. 321.

[7] Since the above was written we have been informed by Mr. Schultz of the Mexican Exploitation Company that the plane was observed by *chicleros* over these lakes, which are called Payegua and which lie south of Lake Chichan Hanab rather than east of it.

and south. A circle over the central portion of these lakes showed a low, flat, grassy beach on the west and rather steep little slopes on the east. It was decided to examine some small hills on the eastern shore of the third lake from the north, and a landing was effected. The hills proved to be entirely natural formations, without even a house mound, and so at 1.24 the plane took off.

FIG. 14—Yaxha lakes and village.

At 1.42 p. m. the main escarpment, running northwest and southeast, which had been noted the day before, was clearly visible on the horizon far to the west. The course for the most part was 150° magnetic, and the altitude about 500 feet without variation. The entries in the notebook record a succession of *bajos*, whose long axes apparently run east and west. The extent of some of these was enormous. In the great majority of cases the *bajos* were bounded on their northern margins by abrupt escarpments, of which the highest might be between 75 to 100 feet, whereas on their southern margins the land sloped gradually until it was sufficiently free from standing water to support a dense and high jungle. One *bajo* was so wide that it required 11 minutes' flying to cross it, or not less than 15 miles for its shorter axis. Black water beneath the scanty vegetation was visible in all the *bajos*.

At 2.10, or about 55 miles from the lakes, a prominent whaleback hill was noted to the west, slightly ahead of abeam, and another extensive *bajo* on the east. A small hill north of the whaleback caused us to change our course from 180° to 225°, in order to inspect it; and on the way there, about eight miles, the silhouette of the whaleback was clearly visible. It showed no signs of ruins or terracing. Arriving over the little cone-shaped hill, we circled it several times; but, although the sides were very steep so that it appeared artificial, it was not possible to determine whether this was the case or not. Its

large size was a factor militating against the probability of artificial construction.

At 2.39, 106 miles from the lakes, at an elevation of 1000 feet, we crossed the Rio Hondo. The heavy rains had completely inundated large portions of the valley, which was bounded on the north by an escarpment. Presumably we crossed somewhere between Orange Walk and Corozal, for at 3.50, after several circlings at an elevation of 2000 feet, Chetumal Bay was plainly visible. Local rainstorms concealed Bacalar Lagoon. At 3.00 p. m. Corozal was seen on our left (east). Thence the coast was followed to Belize, with one swing inland, and a landing was made in front of Newtown Barracks at 4.06—4 hours, 23 minutes flying time from Merida, or approximately 373 miles, with 2 hours, 8 minutes spent at the lake.

Flight of October 8, Belize to Flores and Return
South of Cockscombs

The plane rose from the water at 9.25. The course (about 210° magnetic) was, as on October 6, set for El Cayo. Visibility was better than on the previous flight. At 9.35 a. m., 20.6 miles from Belize, the plane turned southerly toward some small steep hills, one of which was topped by a tripod Indian shrine exactly like the one seen near Vaca Falls on October 6. White objects like large conch shells or bones could be made out on the ground in and about the structure. The course to El Cayo was then resumed.

At 9.47 the notebook entry reads: "Flying over extensive 'pine ridge.' Hills running E. and W. extend along S. of this 'pine ridge.' There is no 'pine ridge' visible to the N. of us. On the S. clouds hide the height of land, but to the E. is a long upward incline where the land rises to form the highlands of Guatemala. The silhouette of the Cockscomb Mountains is very jagged and broken." The plane was then at 1000 feet, and throughout this flight a greater average altitude was maintained than on the previous two days. About 9.55 we were over a loop of the Belize River. It was noted that even so considerable a stream as this could not be seen because of the very high forest along its banks until the plane was almost directly above it. A group of natural hummocks on the east bank was studied. They showed no regularity of spacing, their bases merged, and the tree cover was of exactly the same character as that of the surrounding terrain. The milpas here were of irregular round or oval shapes, and in old ones was a heavy growth of corozo palm.

At 10.04, 55.4 miles from Belize, altitude 1300 feet, the country to the south was distinctly rougher. At 10.10, 63.9 miles, El Cayo was passed; at 10.15 Benque Viejo lay behind, and both Yaxha lakes were in sight. Between 10.20 and 10.30 a circle was made to the north

in an effort to find the ruins of Naranjo, but the hilly nature of the terrain added to the difficulty of spotting this ruin through the jungle; as it could not be seen, the plane was headed for Yaxha.

We circled the supposed position of the Yaxha ruins and soon made out on the high north bank of the west lake an elevation in the forest, which at a distance had the appearance of an extra large, blue-green tree top. When we came close in, however, it proved to be made up of many trees, rising pyramid-like above the general level of the vegetation. Through the foliage glimpses could be caught of gray stone, and this we thought to be masonry. To make sure that the object under observation was actually a temple substructure, we landed on the west lake at 10.35 (Fig. 14). From this position the terraced silhouette of the ruins, which lie on high land, was easily recognizable against the sky. At 10.38 the plane left the water, passed again over the site for further observation, and headed for the ruins of Nakum, which were reached at 10.45 and easily identified by a tower temple protruding above the jungle. Nakum was cleared by Maurice de Périgny in 1910; and, although the vegetation had reëstablished itself about to the height of the surrounding forest, it was of finer texture and lighter color. This appears to be true of all second growth. Several minutes were devoted to close scrutiny of the mounds, and it was noted that from directly above they present a squarer plan and more orderly arrangement than do natural hummocks. Nakum, it was noted, lies in a plain with an escarpment on the north, the rain-swollen Rio Holmul being distinctly visible.

From Nakum we headed to Tikal, passing across a large *bajo* of more irregular shape than is shown on the Shufeldt map. The *bajos* of the Petén are grayer green than the "high bush," and the surface of their tree tops is very much smoother.

A stream running north-south was crossed between Nakum and Tikal, and the latter site was below us at 10.57. Particular attention was paid to the lesser mounds. They were seen to be marked by a heightening and bunching of the bush and a definitely darker green color of the foliage (Fig. 17). The *aguada* was easily located. We swung off at 11.02 for Uaxactun, where the same observations were repeated, and left at 11.15, heading east, the magnificent silhouette of the Tikal temples clearly visible to the south. The eastward turn was made for the purpose of examining the suspicious lumpiness of a ridge about six miles away, but when we reached the place the lumpiness was seen to be caused by a group of unusually large trees. We accordingly took a southwest course (210°), passing between Uaxactun and Tikal at an altitude of 1500 feet.

The next fifteen minutes gave splendid opportunity for study of the great Petén forest. It is a much brighter, richer green than the growth near the coast. Its upper surface is not flat, like that of the

bajos, but slightly lumpy, an appearance caused by the more or less regular distribution of a dark green, thick foliaged tree of somewhat higher habit than the general mass of vegetation. The forest cover is unbelievably dense and matted, the ground being nowhere visible and no break occurring save where a great tree has fallen and brought down its lesser neighbors.

At 11.34 the plane crossed a large oval swampy savana, full of water under tall reedy-looking grass. On its north rose a very sharp limestone escarpment, sufficiently steep in two places to show perpendicular cliffs rising 50 to 75 feet. In one of the cliffs was an apparently deep cave some 50 feet long by 15 or 18 feet high. Situated as this grotto is, in the heart of the Old Empire region, it is well worthy of future investigation.

At 11.40 we sighted Lake Petén (Fig. 15), many milpas and thatched huts fringing its northern shore. Several circles were made over the Tayasal Peninsula, whose sparse, feathery trees widely spaced on grassy land, permitted a clear view of the temple mounds and the excavations made for the Carnegie Institution by Dr. Guthe in 1922 and 1923. We then landed at the island town of Flores (Fig. 16). Taking off again at 12.30, the plane headed south. The town of Santa Ana was passed immediately after we crossed an extensive area of low, hummocky hills very uniform in size and height. To the south the land became much flatter, jungle giving way to extensive, short-grass savana, in which grew isolated clusters of pine trees. It was noted that milpas were cleared all about their edges but that the savanas themselves showed no sign of cultivation. Many places in this terrain were judged by Colonel Lindbergh to be suitable both for landing and taking off.

Nineteen or twenty miles from Flores, at 12.44 p. m., the plane crossed over two narrow lakes whose long axes ran east and west; these do not appear on the Urrutia or Blom-Ricketson maps. About 17 miles farther the hills on the east were noted as paralleling our course and as being steeply conical and rough. The jungle was very thick and green, and a scarcity of palms was noticeable. From here on streams were observed frequently, the general course of the drainage being apparently south and southwest.

At 12.59, 41 miles south of Lake Petén, a range of very rough hills, running east and west, was crossed in three minutes. This brought us over another plain, where *guano* palm was seen but no *botan* palm. About six miles from the above-mentioned hills the plane was approaching another range, extremely steep, whose sheer white limestone cliffs at first suggested the masonry walls of temples. From 1.15 to 1.22 p. m., on an easterly course, altitude 1500–1700 feet, the plane flew over a terrain composed entirely of limestone hills, below whose steeply conical tops sheer cliffs dropped away into

FIG. 15

FIG. 16

FIG. 15—Lake Petén, town of Flores, and Tayasal peninsula.
FIG. 16—Town of Flores.

deep gorges. Streams were seen in abundance, and many macaws were noted flying above the dense, matted jungle below us.

After getting out of the worst of the country described above, we passed an Indian settlement with houses in the milpas. At 1.30, 85 miles from Lake Petén, was a large area of milpas cleared on the tops of low, rounded hills. The Indian villages connected with the milpas evidently lie close to the Guatemala-British Honduras boundary, southeast of San Luis, Guatemala (Fig. 18). When the plane was at an altitude of 2000 feet the sky line on the south showed a jagged, steeply conical silhouette.

At 1.43, at an elevation of 2000 feet, the Bay of Amatique in the Gulf of Honduras was visible; before us stretched a vast plain, sloping to the sea. Mountains bounded it on the north, and a compact island of high hills, sufficiently steep to show white limestone cliffs on their flanks, rose from the plain to the south. Just north of the hills were lakes, the surrounding terrain much flooded. Bush houses, with many milpas out on the lower slopes of the hills, were now visible.

At 1.50 p. m., at 1500 feet altitude, we encountered a severe local rainstorm. At 1.55 the plane flew out of the storm and passed over the coast of British Honduras, about 10 or 12 miles north of Punta Gorda. A landing was made on the water near Cary Cay (?), and at 5.05 the plane resumed its flight towards Belize, arriving about 5.50 p. m. The total time in the air on this day was 5 hours, 14 minutes, or about 443 miles.

Flight of October 9, Belize to Cozumel

The plane took the air at 10.23, heading northeast by north for the Rio Hondo. The country on this course between Belize and New River is a low, flat plain, its seaward edge bordered by mangrove, with low mixed forest on the drier inland portions. The bush was much less dense than that of Petén, and through the trees one could often see the ground. No high land could be made out to the west, but visibility was poor on account of local showers in all directions.

At 10.43, 28 miles from Belize, altitude 500 feet, a long, narrow lake was in sight to the southwest and the ocean to the east. Below were many sloughs; the whole region was greatly flooded and would appear to be much too swampy for permanent habitation. Corozo palm became commoner. At 10.50, 46.5 miles, sloughs and small lakes were in sight everywhere between the pine ridges, and higher land with an even sky line lay along the western horizon.

New River was crossed at 11.00 near Orange Walk. Scattered about the settlement were irregularly shaped milpas. In one was a small conical mound. We were over the Rio Hondo at 11.04, the river being out of its banks and the whole region thoroughly soggy.

FIG. 17

FIG. 18

FIG. 17—Temple mound at Tikal (indicated by arrows), showing appearance of such structures when completely covered by vegetation.

FIG. 18—Indian village near British Honduras-Guatemala boundary.

Crossing the Rio Hondo we altered the course to 33°, and in 17 minutes, 24 miles, we were over the western shore of Lake Bacalar, which appears to be much more crescent-shaped than shown on the maps,[8] also about five miles nearer Chetumal Bay than mapped. From this point we headed due west across a very large *bajo*, on the northwestern edge of which the ground rose in gentle hillocks along whose skirts were groups of suspicious looking elevations believed to be mounds but showing no masonry (Ruin I?, Fig. 1). About 15 minutes, 21 miles, west of Bacalar and five miles west of the western edge of the *bajo* was a pronounced north-south whaleback ridge, perhaps five miles long. Three miles north of its northern end in flat, densely forested country we came over a group of five mounds (Ruin II), the tallest about 50 feet high and showing among the trees that shrouded its summit a fragment of masonry wall. We then flew south along the western side of the ridge and about three miles south of its southern end picked up four steep, high pyramids (Ruin III), upon two of which were temple ruins, one of them having what seemed to be a vertically slotted wall. A small *aguada* lay close to the mounds with a rectangular milpa just east of it. From 11.30 to 11.40 we were over the whaleback and the two groups of ruins, circling very low for close observation.

The mounds just described evidently form parts of a large and important city. The larger group (Ruin III) is doubtless Tzibanché, discovered and named by Dr. Thomas Gann in 1927.[9] The smaller group (Ruin II) was not visited by Dr. Gann, whose exploration of the region was cut short by malaria; and it is possible that associated with it may be hieroglyphic monuments, not found at Tzibanché, that will permit accurate dating of this obviously Old Empire site. Tzibanché is located too far south on the Blom-Ricketson map; it lies, according to our reckoning, about due west of Lake Bacalar; and this position is confirmed by the description of Dr. Gann.[10]

At 11.50 we rose to 2000 feet to get our bearings, observing an extensive north-south escarpment ten miles to the west. We then headed slightly east of north across absolutely flat country. After about 12 minutes' flying, 17 miles, a sharp elevation came into view on the northern horizon, and 14 minutes, 19.7 miles, brought us over it. During that interval several small lakes were seen to the west and one about six miles to the east.

The elevation proved to be a pyramid about 75 feet high (Ruin IV). One hundred yards east were three lower pyramids, and the forest all about had a suspicious lumpy appearance which seemed to indicate

[8] The crescent opens to the east. The exact shapes of lakes in low country are difficult to determine during the rainy season, because of extensive flooding which, on the other hand, gives valuable indications regarding details of contour of surrounding terrain.

[9] T. W. F. Gann: Maya Cities, New York, 1928, pp. 77 ff.

[10] *Ibid.*, p. 77.

the presence of a number of smaller mounds. We dropped and circled within a few feet of the tree tops and close in against the tall structure but were unable to distinguish masonry. The Blom-Ricketson map, 1929 revision, shows no ruins in this area; and the site, apparently a fairly extensive one, is presumably new.

At 12.20 we pulled up to 500 feet (the most advantageous height from which to pick up surface irregularities) and headed again slightly east of north. There were many milpas in the neighborhood of the last ruin, some of them with single palm-thatched huts (granaries?). The forest now became noticeably lower and drier; one very abundant tree, rising slightly above the general level, seems to be leafless at this season, and its light-colored branches and twigs give a hazy, grayish effect to the bush, a tone quite distinct from the rich green of the higher forest.

At 12.29, when 12.7 miles north of Ruin IV, we sighted in a clearing an Indian town of six or seven palm-thatched houses. The country was dead flat, the bush still lower and grayer, and small white rain squalls were all about. Another village appeared and there were many milpas of all ages. In several of the newly cleared milpas were great numbers of little (house?) mounds set so close to each other as nearly to touch. Although their size was difficult to estimate, they seemed to average 15 to 20 feet in diameter by 2 to 4 feet high. Some were rounded, others flat-topped. Their abundance might make it appear doubtful if they were of artificial construction; but we can think of no natural agency that could produce them, and Dr. Morley informs us that the modern Maya consider areas densely covered with ancient remains as the best land for corn culture.

At 12.39, nearly 27 miles from the last site there was observed in a large, freshly cut milpa a flat-topped mound about 50 feet square and 10 feet high with small conical mounds clustered around it (Ruin V).

Four minutes later Mrs. Lindbergh sited an eminence on the western horizon, and we turned at right angles to a course slightly north of west to examine it. We immediately passed out of the milpa country, and the bush gradually became higher and greener. At 12.49 another pyramid was seen to the north, and the tops of rounded hills could be made out far to the south. As we approached the first pyramid (Ruin VI) at an altitude of 300 feet we could make out that it lay on the northern end of a low north-south ridge—the only one in sight. We came over at 12.59, 16 minutes' flying time, or about 22.5 miles from the point from which the pyramid had originally been picked upon the horizon. It turned out to be a steep, high mound set slightly back from the tip of an inconsiderable natural elevation. The stonework of a ruined temple could be made out, and nearer the end of the ridge were two or three lesser mounds. A

slough lay just north of the high ground and beyond it a large milpa. Near the mounds was a small clearing with a hut; we saw an Indian woman in a pink dress and several naked children who ran into the house as we circled downward. The location of the site would seem to be about 30 miles due east of the mapped position of Lake Chichan

FIG. 19—Keys off southern coast of British Honduras.

Hanab. No ruin near this supposed location is shown on the Blom-Ricketson map.

At 1.01 p. m. the plane was leveled off northward at 500 feet in bumpy air and at 1.04 took a northeast course for the pyramid seen while we were on the west tack. We lost it for a few minutes, dropped lower, and picked it up again, and then (1.06) discerned another to the southeast. At 1.10 we suddenly found ourselves over a large mound flanked by a smaller one (Ruin VII); these we had not made out from a distance. There were no villages or milpas anywhere about. A minute or so later, seeing what we thought were mounds at the far edge of a cloud shadow about a mile to the west, we headed for them but found nothing there. Our mistake was caused by a peculiar illusion (noticed several times later that afternoon) produced by the looming to unduly large proportions of any slight irregularity of the forest carpet near the division line between cloud shadow and sunlit bush.

At 1.20 we were still pointed for the mound first seen on the detour to Ruin VI. At 1.21 we came over milpas and at 1.25 passed an extensive new clearing containing many low, rock-strewn mounds. The bush was dry, and no lakes were to be seen in any direction. At 1.27 four ruins were in sight: the one we were flying for, two of lesser size to the southeast, and a most imposing group of mounds on the northern horizon. As the last was obviously an extremely large site, and as our gasoline was getting low, we decided not to beat back to the southeast mounds and continued a trifle east of north until we

had passed over Ruin VIII, a pyramid smaller and less steep than that of No. VII, standing on a slight ridge and dominating several smaller structures. No masonry could be seen.

All eyes were now glued on the big group to the north. By dead reckoning we were still far south of the supposed position of Coba,

FIG. 20—Ruins of Tulum temples with encircling wall, eastern coast of Yucatan.

the only known city in this region rivaling in size the one we were approaching. At 1.30 there could be made out a very tall steep pyramid; close to it a great squat mound with lower mounds all about. The bush was very dry, sparse, and thin-leafed, so that glimpses of rocky ground could be had between the trees; but as we made northing the vegetation rapidly grew higher, thicker, and greener until when we came over the big ruin at 1.45 it was almost as dense as that of Petén.

To our surprise and chagrin (for we had had visions of a major new city) we found ourselves above the twin lakes of Coba. We dropped to circle the tall pyramid. It proved to be the "Castillo" of the Nohochmul subgroup, visited and photographed by Maler twenty or more years ago and revisited by Mr. Eric Thompson and Dr. Kidder of the Carnegie Institution in 1926. The temple on the summit was discernible through the trees and was recognized by Colonel Lindbergh as the ruin seen by him on his flight with Mr. Hambleton. All the major structures of the city were easily recognized—the Macanxoc mounds,[11] the massed buildings on the lake shore, etc. When we came down to the level of the tree tops and could look horizontally across the jungle, many other mounds, not visible from above, were seen in every direction.

An attempt was made to land on the larger of the two lakes, but

[11] Discovered by the Carnegie Institution expedition under Mr. Eric Thompson in 1926. The hieroglyphic stelae at Macanxoc, deciphered by Dr. Morley, record the dates 9.9.10.0.0 to 9.12.0.0.0 (354 to 413 A. D., according to the Morley-Spinden correlation), proving that Coba was founded in the Old Empire. It was doubtless the principal northern city of this early time; but the architecture of certain temples shows that it was occupied well into the period of Toltec influence.

after skimming the water Colonel Lindbergh decided not to risk a take-off with so large and so heavily freighted a plane, because of the high trees on its shores. We accordingly went up and steered south of east for the coast. At 2.04, altitude 900 feet, the sea appeared and the bush became again low and dry.

At 2.15 we were over the coast city of Tulum, its ruined temples on the rocky shore presenting a most beautiful sight (Fig. 20). The flight from Coba had taken 19 minutes (26.79 miles—but the distance may be somewhat more, as a note appears that our air speed was at this time over 90 m. p. h.).

After circling for photographs we landed on the sea inside the barrier reef, went ashore in the rubber boat, and spent a little over two hours examining the ruins. We met some native *chicleros* who told us that Coba is the only large city in the interior of this region. They also said that by trail it is 14 leagues, that is about 35 to 40 miles, from Tulum to Coba.[12]

We left Tulum at 4.35 for Cozumel. The island came into sight, a long low line on the northeastern horizon at 4.40; at 4.55 its southwestern coast was crossed, and a mound (Ruin IX) was visible in the northern interior. This we flew over; it was some 60 feet square by 20 to 30 feet high and was flanked by smaller mounds. It does not appear on the Blom-Ricketson map. We then circled back to the town of San Miguel, landing at the Pan American Airways ramp. Flying time for the day was almost exactly 5 hours, or a distance of 425 miles at 85 m. p. h.

Flight of October 10, Cozumel to Coba to Havana and Miami

After visiting a small ruin discovered during construction of Pan American Airways landing field just north of San Miguel, we took off. A heavy ground swell in the channel made rising difficult, but we taxied to smoother water near shore and got into the air at 9.24.

Thinking that we might perhaps have been in error the previous day in locating Coba so far to the south, we took an almost due easterly course from San Miguel, crossed the mainland coast at 9.32 (8 minutes, 11.28 miles—this agrees very closely with the map distance). The shore line was gently scalloped, edged with snow-white sand, and not cliffed as at Tulum. It was raining, and visibility was poor. The bush inland was high and green with little or no palm and so dense that the ground could not be seen. There were a few rectangular milpas close to the coast, none in the interior. At 9.42 we came over a small *cenote*[13] and immediately thereafter crossed a straight, well

[12] The league of the *chiclero* is the distance a loaded mule travels in one hour, about 2½ to 3 miles.

[13] Sink hole caused by breaking in of the roof of a subterranean chamber in the limestone formation. *Cenotes* provide the only access to water in many parts of northern Yucatan, where lakes are rare and surface streams nonexistent.

cleared trail running northwest to southeast, probably the Chemax-Tancah road. At 9.45 (21 minutes, 30 miles from San Miguel) the pyramids of Coba were seen to the southwest. We straightened away on that course and at 9.47 (12 minutes, 17 miles) were over the lakes, having passed on the way a second *cenote* set about with what we took to be small mounds. The true position of Coba appears to be at least 15 miles south of that shown on the maps, or almost due west of the southern tip of Cozumel Island.

Our purpose in revisiting Coba was to attempt to pick up and, if possible, follow the ancient masonry causeway (*sacbé*) that runs west from Coba and is said by the natives to end at Yaxuna south of Chichén Itzá. Similar causeways radiate in other directions from Coba. They apparently were laid out in straight lines from point to point; and, as they are raised somewhat above the surface of the ground, it was thought that a corresponding elevation of the trees growing upon them might render them visible from the air or that they might be marked by some difference in the color or texture of the forest cover. Could they be followed by plane they would of course prove invaluable guides for the location of the cities at their terminations.

The Coba–Yaxuna(?) causeway had in former years been traced west for some 15 miles by the Carnegie Institution's ground parties, and its point of origin in the Coba ruins was accurately known. In spite of this we were unable to see it, although we flew over it both high and low and looked most carefully. There was, however, no sun—the visibility being dead and flat. We believe that in clear weather, early in the morning or late in the evening, when the longest shadows are cast and relief is sharpest, the causeways might be located. Further attempts should certainly be made.

Six minutes were devoted to the search and to further observations of the ruins. The Coba bush is extremely dense and lush, closely resembling that of Petén. There are in the neighborhood two other lakes, somewhat smaller than those at the site.

By 10.06 we had left Coba and taken a northeast course for the coast. The weather became steadily thicker, the ground at 600 to 1000 feet being often invisible. We passed over a region of what, for want of a better name, we called "high-low," a peculiar type of bush with level undergrowth, apparently about 10 to 15 feet high, regularly spaced with large, tall trees. The latter are not densely foliaged and evidently permit the sun free access to the lower stratum. At 10.15 we crossed the (Chemax-Tancah?) road again and at 10.18 came into a sharply defined area of almost leafless trees. At 10.26 we crossed the shore line at Puerto Morelos and struck out for Cuba. We reached Havana at 2 p. m., refueled, and came into Miami just as a stormy, windy night was falling.

Including the one hour spent over the Coba country on this day, the total of archeological flying was twenty-one hours, during which time about 1780 miles of territory were covered. How long would be necessary to traverse the same routes on the ground is beyond all computation, for much of the territory is unbroken wilderness entirely without trails; and such stretches as those from Uaxactun to the southern settlements of Yucatan and down the western side of the Cockscomb Mountains could be crossed only by large, well equipped expeditions that devoted weeks or months to the work.

The flights were planned and carried out purely as a reconnaissance in order, as was said at the beginning of this paper, to determine whether or not the airplane could be utilized as an adjunct to scientific, particularly archeological research in regions densely overgrown with tropical jungle. The answer to this question was decidedly affirmative.

Use of the Airplane for Research in the Maya Area

It is most difficult to summarize the impressions of an experience so novel and so exciting. Our results were, of course, less full and less precise than could be wished, but it must be remembered that both the writers were entirely unpracticed in air observation. We improved, however, with every hour and toward the last found ourselves able to see and to record not only the principal features of the country we were passing over but a considerable amount of detail. After discussing the technical aspects of the problem with Colonel Lindbergh we have reached the conclusion that an intensive survey of the region would amply justify its cost.

Among the greatest hindrances to Maya research are, as has already been pointed out, the extreme difficulty and slowness of ground travel and the inability of the explorer, because of the density of the vegetation, to gain a comprehensive idea of the topography of the region he is working. Such drawbacks are largely removed by the speed of the plane and its freedom from earthly barriers. The airplane's greatest value for such country lies without doubt in the geographical information it renders so easily and quickly available. The major relief and the drainage systems of the interior can be recorded with reasonable accuracy on preliminary flights. They can then be located more closely by flying to them on straight, timed compass courses from known stations on the coast. In many cases absolute precision can be attained by landing on lakes, rivers, and savanas for astronomical observations, which in turn may be used to cross-check the rougher determinations from coastal points. Oblique and vertical mosaic photography should, of course, be employed to fill out the picture. There can also be studied less prominent but,

from the archeologist's and biologist's points of view, no less important features. Different types of vegetation, for example, proved highly characteristic and were extremely easy to recognize from the air. Given a reasonably complete outline map of the area, its forest cover could be plotted in detail, and thus invaluable data could be provided as to nature of the soil, local meteorological conditions, and minor aspects of relief.

Lastly, ancient cities can be discovered and their size can to some extent be gauged. In flat country this is a relatively easy matter, as was proved by the flights of October 9; and even in more broken terrain, where artificial mounds are difficult to distinguish from natural hills and hummocks, further training by close study of the appearance of known sites will, we are confident, produce good results. The bird's-eye view attainable from the air renders easy the finding of sources of water supply such as *aguadas* and *cenotes*, and near these one may expect always to encounter ruins. With a little practice one can learn to recognize the sort of terrain the Maya were accustomed to pick for their temples and what varieties of trees flourish on the soil best fitted for their system of agriculture. Thus much barren territory can be disregarded and all available flying time be devoted to examination of the areas most likely to have been former centers of population.

These are some of the uses of the plane as a direct fact-finding agency. In addition it should serve as a means of transportation. Much of the time and cost and most of the danger of disease in tropical exploration are entailed by the journeys from the coast to the scene of work. The large expedition operating over several months must, of course, always go in as usual, but there are many special investigations, both archeological and biological, which might well be conducted by small parties in short periods of time. One can, for example, fly from Belize to Lake Yaxha in about an hour; to Lake Petén in an hour and a half; to Lake Bacalar in an hour; from Cozumel to Coba Lake in half an hour; and to the interior lakes of northern Yucatan in an hour and a half. Lightly equipped groups could easily be landed on these or other lakes or rivers and be picked up at the conclusion of their studies, the plane meanwhile carrying out other missions.

An air survey of the whole area could be made in four or five months. Flying should presumably begin toward the end of the rains and continue well into the dry period, in order that forest conditions during both seasons may be observed. The ship should, as a safety factor, be twin-motored; should be equipped for easy conversion for use on land or water; and should carry wireless. Flights would naturally be made from various bases: Belize, Cozumel, Merida, points on the Campeche coast, Guatemala City (for the Highlands), etc.

The air staff should consist of pilot, radio operator, observer, and cartographer, one of the latter serving as photographer. A careful schedule should be worked out in order that there might be carried in rotation over certain areas specialists in geography, geology, biology, forestry, and meteorology detailed by governments of the countries concerned or sent out by allied scientific institutions. Some of these persons would also be attached to the landing parties set down at various interior points. Endeavor should furthermore be made to induce all agencies interested in the Maya field to have ground exploration parties at work during the months of the survey. Close touch would be kept with such parties by radio or by prearranged smoke signals, and rendezvous would be established at places where the plane could land. The explorers would then be taken over the region of their work to check their observations, to study topography, and to lay out routes for future travel.

An intensive survey of the sort here outlined would require thorough planning and skillful organization. It is, however, perfectly feasible; and its results would be of outstanding value to many branches of research. Colonel Lindbergh has assured the writers of his interest in the project and of his willingness to further it in all possible ways.

METEOROLOGICAL SERVICE FOR AIRWAYS IN THE UNITED STATES

Willis Ray Gregg

U. S. Weather Bureau

THE vital importance of an adequate weather service for aeronautics is no longer a subject for debate. It is universally recognized. Striking evidence of this fact comes in daily to the Weather Bureau. Appeals for more service are received from all parts of the country. A leading air mail contractor says that nearly all of the troubles experienced by his company in the course of a single year were traceable, directly or indirectly, to weather. The "troubles" are mostly concerned with delayed and canceled schedules and therefore loss of revenue but in some cases are more serious still, involving a damaged plane or even the loss of life.

It is easy to say in general terms that "weather" causes these troubles. But, more specifically, what particular features of the weather chiefly cause them? A blanket of fog kept planes on the ground for a week between Chicago and Kansas City. With zero ceiling and zero visibility—and that is what fog means—a pilot risks all if he ventures up.

Low clouds and high mountains form a dreaded combination in the Siskiyous and Umpquas of the North Pacific coast. A cloud canopy frequently hangs over San Francisco Bay in the summer months. Ice on the plane is a hazard second to none and is a source of constant anxiety in the Northeast during winter. The conditions favorable for its formation are now the subject of investigation.

And there is the thunderstorm, from which no part of the country is entirely free but which attains greatest frequency in summer in northern New Mexico and the eastern half of the Gulf of Mexico. It is customary for some to make light of its dangers. But no pilot who has ever been through a bad thunderstorm will venture into another willingly. What to do when they are reported—go round them or await their passage—depends upon their size and intensity, and so the weather reports must include these details.

The Air Commerce Act

Until the Air Commerce Act came into force on May 20, 1926, there was no regulation of civil aeronautics in the country; or, rather, there was regulation of various sorts in different states, with hopeless

confusion resulting. The Air Commerce Act provided the proper authority for changing this. Machinery was set up for issuance of regulations, licensing of pilots, classifying of airports, and inspection of aircraft. For this work the Aeronautics Branch was organized, under an additional assistant secretary, in the Department of Commerce.

An equally important part of Federal encouragement and support of aeronautics is the provision of navigational and other aids, such as emergency landing fields, beacon lights, prompt communication facilities, and adequate weather service for all flying activities on Federally established civil airways. Except for the weather service, responsibility for providing these aids was placed in the Bureau of Lighthouses, of the Department of Commerce, a new branch known as the Airways Division being created for this purpose.

The work of organizing and maintaining an adequate weather service was naturally assigned to the Weather Bureau, whose already existing elaborate system of reports and forecasts for general public needs made necessary only an extension along similar lines, though in more detail, to meet the requirements of pilots. As authority for this service, the Weather Bureau's organic act was amended to include specifically the furnishing of weather reports, forecasts, and warnings "to promote the safety and efficiency of air navigation in the United States and above the high seas, particularly upon civil airways designated by the Secretary of Commerce under authority of law as routes suitable for air commerce."

Before the development of this special service during the past three years is traced it is well to note the character of the foundation on which it has been erected.

The New Weather Service and Its Antecedents

In the course of some fifty-five years the Weather Bureau developed a system of reports and forecasts, which provided the basic data for public needs. There were about two hundred regular stations, well distributed over the country, at which technically trained personnel made observations, received and charted twice daily reports from other stations, issued bulletins and forecasts based on these reports, and maintained complete and accurate records of the various meteorological elements at these stations for use in statistical and other researches. The most important phase or feature of this service, so far as the public is concerned, is the twice daily issuance of forecasts. These are based on the well known synoptic weather maps with their characteristic "highs" and "lows," lines of equal pressure and temperature, and arrows pointing the direction of the wind. The maps are made up at nearly all the two hundred stations, although

FIG. 1

FIG. 2

FIG. 1—The Shenandoah flying through the Golden Gate.
FIG. 2—Advection fog, seen from Mt. Wilson, California (Photograph by F. Ellerman).

they are issued in printed form at only the larger ones. Five of the stations, Washington, Chicago, New Orleans, Denver, and San Francisco, are District Forecast Centers, each having charge of a large area and furnishing forecasts therefor. The forecasts, which include general weather, temperature, and in many cases upper air conditions, are given wide dissemination by telegraph, telephone, radio, and the press.

In addition to these more or less general predictions of the larger changes in weather, localized forecasts are made for smaller areas and individual cities. Moreover, several detailed and intensive services have been organized to meet special needs, and thus we have what are called the "fruit frost," "harvest weather," "forest fire," "river and flood," "corn and wheat region," "cotton region," and "storm warning" services. For these the twice daily reports from about two hundred stations are supplemented by additional reports from places so located as to give the information needed. The observations are made by properly instructed though not technically trained personnel. They are sufficiently accurate for the purpose but are not of the high degree of precision required at the two hundred stations which compose what may be called the Bureau's primary service. Whereas the primary service functions throughout the year, the reports from special or secondary stations are sent only as needed. By means of telegraph and telephone the reporting system can be quickly used to give warning of floods, hurricanes, etc.

In spite of the previous experience in other branches of the service, however, it was necessary to do considerable experimenting on the new branch for flying activities, especially in the early days. For that matter the pioneer stage has not even yet completely passed. New ideas are constantly being tried out, while changes in operating conditions along the airways, particularly in communication facilities, may and sometimes do render obsolete today what was the most efficient and satisfactory arrangement yesterday. Nearly all of this has to do with details, however. The principal features of the service, as set forth in the beginning, remain unchanged. They are:

1. Frequent reports showing current conditions, both surface and upper air.

2. Short-range forecasts giving the outlook for one to five or six hours, the length of this period depending upon the scheduled duration of any given flight.

3. General weather forecasts for the next 12 to 24 hours.

Current Reports

First place is given to "frequent reports of current conditions, both surface and upper air." The pilot wants to know, first of all,

what the weather is now, not only at his terminal but also at all points along the line of flight. The first step, accordingly, was to organize a reporting system on all the principal airways. Figure 3 shows the airways being served at present and the stations on or very close to those airways from which reports are furnished. The frequency of the reports varies somewhat, depending on the number of regular

FIG. 3—Weather-reporting stations on and near civil airways at the close of 1929.

scheduled flights. When the service was first organized, the practice was adopted of having reports made to fit the schedules; and this is still followed on a few airways where only two or three flights are made each day. In these cases, if quite regular schedules are kept, the reports are sent by telegraph a few minutes before the flight begins; but, if delays are frequent, owing to the necessity of making connections with other airways or for other reasons, the reports are usually furnished on telephone call from the starting point.

It can readily be seen that this system is satisfactory only so long as the number of flights is small. When flights are numerous and calls for reports are required at frequent and irregular intervals and delayed flights add to the complication, the system becomes unwieldy and breaks down. As rapidly as justified by the amount of traffic and by funds available, it is being supplanted by frequent, regular reports. The question of how frequent these should be is still a debatable one; but the consensus of opinion is that the most satisfactory interval, all in all, is one hour. The plan is being given a thorough trial and is now in operation along several thousand miles of airways.

Naturally the prompt collection of these reports (and unless they are prompt, all the effort is wasted) requires a highly efficient communication system, whose organization is a function of the Airways Division of the Department of Commerce. It was early found that, for this particular purpose, dependence cannot be placed on the ordinary commercial facilities. During the time of peak loads, that is in the middle of the day, absolute promptness could not be guaranteed. All types of business are entitled to equal service. It was evident, therefore, that a system of communications under absolute control is necessary. This has been accomplished on some of the main airways through the installation of a printing telegraph, or "teletype," circuit. The circuits consist of leased telephone lines 500 to 800 miles in length between terminal airports with drops at the intermediate weather-reporting stations, each one of which has an automatic typewriter, or teletype machine. The messages are typed on these machines in sequence, the various stations following one another in rapid succession; and each message is received on tape by all other stations in the circuit. This system of communications is prompt and is rapidly increasing in efficiency and reliability. The Department of Commerce plans to extend it eventually to all interstate trade air routes.

FIG. 4—Weather Bureau office at Oakland Airport. Pilot balloon observation in progress on roof.

All reports, whether sent by teletype, telephone, telegraph, or radio, include information concerning the following elements: general condition of sky and weather; ceiling; visibility; surface wind direction and velocity; temperature; barometric pressure; and miscellaneous conditions, such as thunderstorms, squalls, and state of landing field as affected by rain, snow, etc.

In many cases dew point is also reported, and some of the airport stations—about forty-five at present—give detailed data of wind direction and velocity at various heights.

For the general condition of sky and weather no instruments are required, but certain definite terms have become standard for expressing it, such as "clear," "broken clouds," "overcast," "fog," "heavy rain," "sleet," etc. This first word in the report tells the

FIG. 5—Air mail pilot receiving typed weather report fifteen minutes before the scheduled departure at Oakland airport.

pilot at once whether conditions are satisfactory, impossible, or simply uncertain and therefore subject to further study.

The next two items, ceiling and visibility, usually answer this question of uncertainty. For observations of ceiling at night when clouds are present the so-called "ceiling light" is in general use. A beam of light is shot upward, in some cases vertically, in others at a 45° angle, and in still others at some intermediate angle. The use of this instrument has not as yet wholly passed the experimental stage, but the consensus of opinion is that a vertically projected beam gives the best results. There is still some uncertainty also as to the most satisfactory intensity. At present 250-watt bulbs are in general use, although a higher intensity is favored by some, especially for stations in mountainous country, where high ceilings are essential for safety. In all cases the beam makes a spot of light where it strikes a cloud. This spot is more or less definite and well marked, depending on the density of the cloud mass. The height of the spot, and therefore of the ceiling, is determined by means of an alidade, or protractor. The angular reading of this instrument, together with the known distance of the light source from the point of observation, provides the necessary data. In many cases the alidade is graduated in heights

instead of degrees and thus eliminates the need of computation or the use of tables or graphs.

For observations of ceiling in the daytime, so-called "ceiling balloons" are used. These are about the size of ordinary toy balloons, although of a somewhat better quality. They are filled with hydrogen until just capable of sustaining a 40-gram weight. When released they rise at a known and fairly constant rate. It is then only necessary

FIG. 6—Teletype machines in use at the Oakland, California, Airport Station of the Weather Bureau. The meteorologist in charge and a pilot are reading the weather reports as received on the teletype tape.

to note accurately the exact time of their disappearance in the cloud. As in the case of ceiling lights, when the cloud mass is of a light and tenuous nature, there is some slight uncertainty as to the exact moment of disappearance, and it is general practice to report the height at which the balloon begins to be indistinct. Ceilings are usually given only to the nearest hundred feet. Greater precision is not warranted in view of the fact that the cloud base itself varies as much or more within relatively short distances.

Observations of visibility are non-instrumental. It is customary to give the greatest distance at which conspicuous objects can be clearly seen. Whenever practicable, lights are used at night. This method is approximate only, but fortunately it is most nearly accurate at times when the information is of most importance, that is when visibility is low. It should be stated that observations of visibility show conditions in the horizontal, not in the vertical. No

attempt is made to measure vertical visibility except when clouds are low, in which case it is defined by the height of the ceiling.

These two elements—ceiling and visibility—have been dwelt on at some length for the reason that all pilots ask first for information regarding them. Many ask for nothing else if these are favorable. Whereas they were never thought of in meteorology before the days of flying, now they are among the most important working tools of the meteorologist whose duty it is to tell the pilot what the weather is or is going to be.

U. S. DEPARTMENT OF AGRICULTURE, WEATHER BUREAU

AIRWAY WEATHER REPORTS

DATE APRIL 4 1929

STATIONS	ALTITUDE (Feet)	TIME 7:45 Meridian	SKY AND WEATHER	CEILING (Hundreds of feet)	VISIBILITY (Miles)	WIND (Miles per hour)	TEMP °F	RELATIVE HUMIDITY	BAROMETER	MISCELLANEOUS
HADLEY	130	W 46 A	BROKEN CLOUDS	UNL	5	WSW-5	73		30 16	
NORTHAMPTON	380		BROKEN CLOUDS	UNL	5	SW-14	67		.14	
SUNBURY	460		BROKEN CLOUDS	50	3	0	64		.14	HAZY
BELLEFONTE	1040		OVERCAST - THUNDERSHOWER	15	5	SW-12	66		.10	
HARRISBURG	370		OVERCAST SMOKY	15	1/16	SW-10	71		.15	
KYLERTOWN	1700		OVERCAST - HAZY	15	3	SW-12	71		.17	MODERATE RAIN
MERCER	1300		OVERCAST - HAZY	10	4	SW-15	69		.05	OCCASIONAL RAIN
PARKMAN	1200		BROKEN CLOUDS	15	4	SW-12	70		.09	HAZY
CLEVELAND	780		OVERCAST	50	6	S-14	69		—	
HADLEY	130	2 46 P	OVERCAST	UNL	5	SW-5	71	50	30 12	
NORTHAMPTON	380		OVERCAST - THIN	UNL	5	SSW-8	70		.10	
SUNBURY	460		OVERCAST	20	2	SW-20	63		.10	HARD THUNDERSTORM
BELLEFONTE	1040		OVERCAST	15	7	SW-8	67	58	.10	
KYLERTOWN	1700		OVERCAST - LT RAIN	15	5	S-8	66		.13	
BROOKVILLE	1460		BROKEN CLOUDS	12	5	S-10	61		.12	
MERCER	1300		BROKEN CLOUDS	15	8	SW-15	69		.03	
PARKMAN	1200		BROKEN CLOUDS	12	5	SW-14	61		.07	
CLEVELAND	780		OVERCAST	UNL	UNL	SW-10	62		.01	
HADLEY	130	7 46 P	OVERCAST	20+	5	WSW-8	74		30 08	
NORTHAMPTON	380		OVERCAST - LT RAIN	20	5	WSW-10	69		.06	
PARK PLACE	1950		OVERCAST - HVY RAIN	5	2	SSW-20	64		.19	
SUNBURY	460		OVERCAST - MOD RAIN	20	2	SW-8	60		.10	
WOODWARD	1140		OVERCAST - LT RAIN	0	1/4	0	56		—	FOG IN THE PASS
BELLEFONTE	1040		OVERCAST - LT RAIN	20	9	SW-12	69		.04	
KYLERTOWN	1700		OVERCAST LT HAZE	15	7	SW-18	65		.13	
DUBOIS	1400		OVERCAST	7	2	SW-5	56		—	
BROOKVILLE	1460		OVERCAST - LT HAZE	12	5	SW-12	63		.10	
MERCER	1300		BROKEN CLOUDS	20	UNL	SW-14	69		.01	
PARKMAN	1200		HIGH BROKEN CLOUDS	UNL	UNL	SW-10	65		.04	
CLEVELAND	780		HIGH BROKEN CLOUDS	UNL	UNL	SW-12	67		29.98	
HADLEY	130	2 45 P	OVERCAST	20	5	SW-5	73		30 05	DARK IN WEST
NORTHAMPTON	380		OVERCAST	15	4	W-16	67		.09	MODERATE RAIN
SUNBURY	460		OVERCAST - LOWER CLOUDS	10	2	SW-5	68		.07	
BELLEFONTE	1040		OVERCAST	25	9	SW-15	66		0 2n	
KYLERTOWN	1700		OVERCAST	20	7	SW-18	63		.10	

WINDS ALOFT—MILES PER HOUR

STATIONS	TIME	ALTITUDE						MISCELLANEOUS
		500 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	10,000 ft.
HADLEY		SW-16	SW-16	WSW-27	WSW-30	WSW-34	W-20	W-36
CLEVELAND	1 PM	WSW-24	WSW-35	N-46	W-48	W-48		
CHICAGO		WSW-16	WSW-16	WSW-18				

NOTE:- THE THUNDERSQUALL REACHED HADLEY AIRPORT AT 3.00 PM CHARACTERIZED BY A SMART SHOWER OF RAIN AND A SQUALL-WIND FROM THE WEST OF STRONG TO GALE FORCE LASTING ABOUT TEN MINUTES. ELECTRICALLY THE DISTURBANCE WAS MILD APPARENTLY INSOFAR AS THE SOUTH. THE TIME TAKEN BY THE SQUALL TO REACH ALTC. AFTER ITS FIRST VISUAL DISCOVERY IN THE WEST WAS LESS THAN 20 MINUTES. IT CONTINUED EAST, OVER NEW YORK CITY (3.15 PM) AND WAS EXPERIENCED OVER LONG ISLAND, WITH SOME DAMAGE, BETWEEN 3.30 AND 4.00 PM.

FIG. 7—The pilot's information sheet.

Wind direction and velocity at the surface, temperature, dew point, and barometric pressure are all so well known, as also the instruments used in observing them, that only a passing reference is necessary. Information concerning surface wind is useful principally in connection with taking off and landing. Temperature and dew point together determine the likelihood of fog and of ice formation on the planes. Reports of pressure enable the pilots to correct their altimeters, in addition to furnishing the meteorologist with basic data for synoptic charts or weather maps.

Miscellaneous phenomena are observed directly without instruments. They include thunderstorms, line squalls, exceptionally heavy rain or snow, ice formation as reported by incoming pilots, and any other conditions a knowledge of which is useful and at times vital in determining whether or not flights should be made. Special attention is always given to this part of the reports.

For measurements of upper wind direction and velocity, so-called

FIG. 8

FIG. 9

FIG. 8—Mt. Shasta as seen from a plane.
FIG. 9—Clouds over the Siskiyou Mountains in southern Oregon and northern California.

FIG. 10

FIG. 11

FIG. 10—Cumulus forming fog—rare—seen from Mt. Wilson, California. (Photograph by F. Ellerman.)

FIG. 11—Approaching wind storm. Squall cloud, connected with stratus above. Such clouds usually mark the front of severe squalls and have violent upward motion within them, some observations indicating an upward velocity of 20 feet per second.

"pilot balloons" are in general use at airports. These balloons are about six inches in diameter and are made of pure rubber. Different colors are employed to give the best possible visibility against varying backgrounds of sky and cloud. The balloons, when filled with hydrogen, are about 28 to 30 inches in diameter and ascend at a nearly uniform rate of 600 feet a minute. Their ascent is watched with a theodolite,

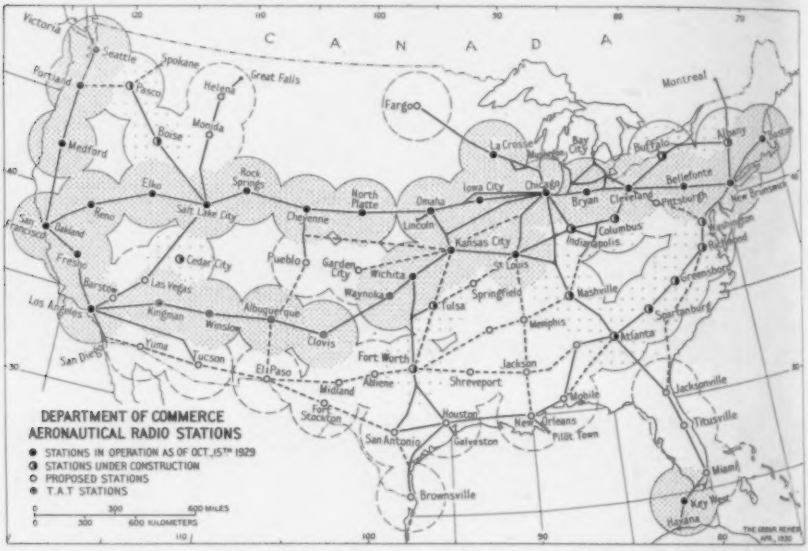

FIG. 12—Radio broadcasting stations of the Department of Commerce.

and angular readings are made each minute. By means of slide rule, portable telephone, and plotting board, computations are made while the observation is in progress, with the result that the wind conditions at various levels are known in detail within two or three minutes after the balloon disappears. For observations at night a small lantern is suspended a few feet below the balloon. Reports containing these data are received as a rule at the Weather Bureau's airport stations, where they are made available in various ways. In almost all cases the reports are posted on a bulletin board. If conditions are generally good, the pilots are usually satisfied with a reading of the bulletin; but, if conditions are uncertain in spots, individual copies are sometimes made for the pilots to take along on their flights.

Whenever conditions are at all uncertain, it is essential that the pilot be kept informed of changes in those conditions even while the flight is in progress. Forecasts of the intensive, short-range type will fill this need to some extent. More will be said on this subject a little later. Unfortunately the time has not yet come when forecasts can be expressed in precise terms. Often when the outlook justifies undertaking a flight, the meteorologist knows that there is

a possibility of bad conditions at the pilot's terminal. In such circumstances radio reports, from ground to plane, provide the pilot with the type of information that enables him to keep to his original plan or to change it if necessary.

Figure 12 shows the development of the radio broadcasting program of the Department of Commerce up to the close of 1929. Twenty-four stations were then in operation, and there will be 15 others by July, 1930. As can be seen from the map, nearly all of the country is included. Only about half a dozen additional stations are needed to complete the picture. It will then be possible for any pilot, flying anywhere and at any time of day or night, to receive just the information he needs, providing he has a receiving set. Although this service has been available a comparatively short time and although only a few planes are as yet properly equipped to take advantage of it, there has already been a 30 per cent reduction in delays and interrupted schedules of air mail planes that are equipped with radio. Captain Hawks, in commenting on the flight in which he recently established a transcontinental record, said:

> I was never so impressed with the value of radio to aviation as I was yesterday Passing Columbus and facing the worst of flying territory at night, I felt qualmish until I picked up Cleveland Airways Radio Station and heard in matter-of-fact tones just the information that I needed—broken ground fog over Pennsylvania and broken overcast with a drizzle over New York. I knew then I could make it.

As a by-product this system of weather broadcasting will be of great benefit to other lines of human endeavor. Considerable use of it is already being made by automobile clubs, and cases are reported here and there of other uses. It is only a question of time when those who need information concerning the weather as an aid in their business will provide themselves with a comparatively inexpensive receiving set and listen in when the reports are on the air. The broadcasts are by radiophone on 285 to 350 kilocycles. Adjacent stations are kept at least 12 to 18 kilocycles apart so as not to interfere with each other.

Short-Range Forecasts

The broadcasts include not only reports of current conditions but also of expected changes for the next few hours. Short-range forecasts have already proved to be a great aid, and it seems certain that, with the increased accuracy that is bound to come, they will ultimately constitute the most valuable feature of the weather service. There is some question as to the most suitable period of time to include in the forecasts. Naturally the shorter the period, the more precise the forecasts; but, on the other hand, their value is limited unless they cover at least a reasonable period. As a proper basis for compromise, the maximum length of the great majority of flights has been chosen, that is three to four hours.

As earlier stated, the basic material for all forecasting is the country-wide collection twice a day of reports which are used in constructing the well known weather maps. Intermediate collections on the same scale would be of tremendous value; but they would also be very expensive, and it is questionable if this cost would be justified by the benefits to be derived. The forecasts for 12 to 24

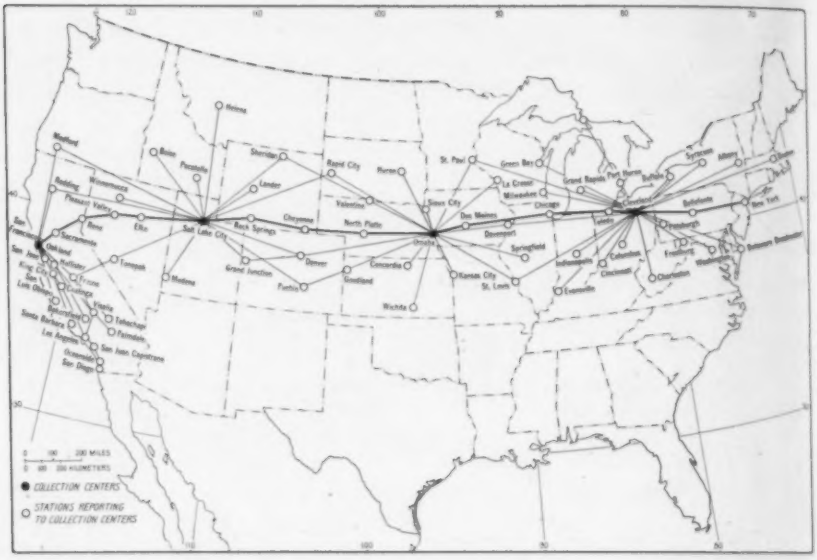

FIG. 13—Three-hourly system of weather reports from off-airways stations along the New York-San Francisco and San Francisco-Los Angeles Airways.

hours, as now issued, are quite dependable but are given in general terms. What is needed is their amplification and localization. For this purpose supplementary reports from relatively small areas are required, small at any rate as compared with the country-wide twice daily system.

As an experiment the period of three hours has been selected, the observations being made at 2, 5, 8, and 11 a. m. and p. m., 75th meridian time. Figure 13 shows the extent of this service at the present time. Although only the New York to San Francisco and the San Francisco to Los Angeles airways are included, it will be seen at once that some of the airways branching therefrom are served in part, such as those from New York to Boston, from Chicago to St. Louis, and others. The stations selected form a belt about 400 miles wide. They send their reports by telegraph or telephone, in a few cases by radio, to Weather Bureau airport stations at Cleveland, Fort Crook (Omaha), Salt Lake City, and Oakland. The data are entered in detail on base maps, and lines of equal pressure are drawn. The maps for 8 a. m. and 8 p. m., 75th meridian time, being based on the Bureau's

primary system of reports, are of course much more complete than are the six others. The latter are used as auxiliary to the former and serve to show the changes taking place in the areas for which the short-range forecasts are issued. For example, the Cleveland station furnishes such forecasts for the New York to Chicago section of the transcontinental airway, basing them on the reports from stations shown in Figure 13. Combined with the forecasts are brief summaries of existing conditions. These are given in some detail if the weather outlook is unfavorable or uncertain. The following examples illustrate the general character of these summaries and forecasts:

July 17, 1929, 8 a. m.: Clear skies prevail. No change of account this forenoon.

November 5, 1929, 11 p. m.: Clear throughout airway, but broken clouds to overcast prevail to northward, from Michigan through central New York; ceilings are ample. Little change next three hours.

October 2, 1929, 2 a. m.: The West Indian hurricane is now moving rapidly northeastward, causing gales, rain, and extremely low ceilings along the seaboard, and its influence has now become predominant as far west as central Ohio; west of Ohio clear weather prevails. Next three hours low ceilings and gales will continue near the coast with rain and lowering ceilings extending to Cleveland; little change west of Cleveland.

December 1, 1929, 11 a. m.: Overcast skies cover western half, and snow is falling in Michigan, Indiana and sections west. Elsewhere fair weather except in immediate vicinity of Lakes where some snow squalls continue. Snow will extend into Ohio and western New York and Pennsylvania next five hours, beginning under fair ceilings which will rapidly decline. Caution advised against ice conditions in all clouds today and against locally severe snow squalls in western half. Southerly winds are increasing. No change eastern third of area next four hours.

December 1, 1929, 5 p. m.: Snow with low ceiling and moderate south winds is falling over western half of area with the front edge of snow still in eastern Ohio; it will advance into western Pennsylvania, New York, and eastern Kentucky next four hours with attendant low ceiling and visibility, and caution is advised against ice and snow squalls this area. Little change will occur in eastern Pennsylvania and elsewhere eastward where clouds are still high or scattered.

The first two were issued during good flying conditions and were therefore brief. The last three are representative of the kind of information given when bad weather prevails and are designed to tell the pilot in detail what he is likely to encounter. It is then up to him or to the operations manager of his company to decide whether or not the flight shall be attempted. This decision is never made and should never be made by the meteorologist. He has his own quite sufficient responsibility of telling what the weather itself will be.

Although designed primarily for flying activities over established airways, the three-hourly system of reports and forecasts in large part also solves the problem of so-called "off-airways" flights. Before the organization of this system there was no provision for obtaining special reports from places not on regular routes, except by special

call and at the expense of the pilots desiring them. Now, however, information is fairly complete for large areas, and any one desiring reports for cross-country flights in those areas has only to listen in at the proper times, since these summaries are regularly broadcast as well as the hourly reports of conditions along the established airways themselves. If the three-hourly system passes from the experimental stage into accepted practice, it will of course be extended to all parts of the country and will serve many interests in addition to those engaged in flying, as indeed it is already doing notwithstanding that it is not yet six months old.

Longer-Period Forecasts

Thus far the need and value of short-range forecasts have been stressed. They are relatively precise and cover approximately the duration of nearly all flights. But they will never do away with the necessity of the longer-period forecasts, to which rather are they supplementary. The 12-to-24-hour forecasts will become increasingly important. While the individual pilot is interested in the weather for a few hours, the operation manager of an air transport line needs to make his plans as far in advance as possible. Particularly is this true if passenger service is included.

Thus the three main features of weather service for aeronautics are each essential to the proper functioning of the others. First, the frequent, individual reports tell of the weather now; second, the short-range forecasts cover the individual flights or announce the weather that is soon to be; third, the basic, general forecasts indicate the likelihood of successful flying tomorrow. Considered in reverse order, the general forecasts form the groundwork of the entire service; they are supplemented by the more intensive shorter-period forecasts; and both of these are still further supplemented by timely reports of current conditions, which check the forecasts previously made and provide data for slight modification in them, if necessary.

The Future

Hand in hand with the organization of intensive weather service, marked advancement is being made in many other lines, each one having as its goal as near an approach as possible to absolute safety and complete efficiency in flight. Some of these efforts are in the direction of improved design and construction of aircraft; others are aimed at the perfecting of navigational aids. Among the former may be mentioned the invention of the auto-giro, which, if it prove successful, will permit planes to take off and land at low speeds and therefore in a very small field. Of navigational aids those of most promise are all associated with radio and include the radio range

beacon, which keeps the pilot on his course in all kinds of weather, and the radio altimeter, which will indicate height above the ground instead of above sea level as is done by the present barometric altimeters.

These and many other inventions will ultimately make flying relatively independent of weather so far as safety is concerned. But the case is entirely different when we consider efficiency. For this the weather service will be the controlling factor. It will determine whether the flying along an airway will be of a haphazard, hit-or-miss variety or of the type that takes advantage in particularly bad weather of every brief break or opening that would enable a pilot to get through. If it be prompt and accurate, it will permit schedules to be kept at a minimum cost by pointing out the levels where tail winds are strongest or where head or cross winds are weakest if no tail winds prevail at any height.

Anything like dogmatic assertion regarding the requirements and possibilities of the future so far as details are concerned should be guarded against. But it is certain that the need for an up-to-the-minute, accurate, and comprehensive weather service will increase rather than diminish. Three years' experience warrants the conclusion that the present organization is built in general along correct lines. As to details, time will point out their needed changes; and these can and will be made as occasion demands.

THE SUWA BASIN

A SPECIALIZED SERICULTURE DISTRICT IN THE JAPANESE ALPS

Glenn T. Trewartha*

University of Wisconsin

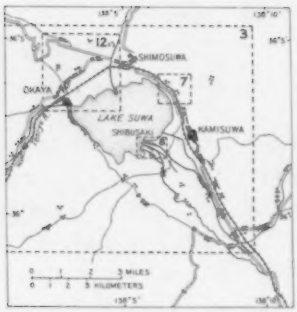

FIG. 1—Lake Suwa, occupying a structural depression in the Japanese Alps and draining northwest by the Tenryu River. For detailed maps see Figures 3, 7, 8, 12.

THE Suwa Basin, in the heart of the mountain knot that forms the central core of Honshiu, exhibits, within a restricted area, landscapes both natural and of human impress that are characteristic and typical of Japan's most specialized silk-producing region. It is a compact sample of a much more extensive landscape and as such attracted the writer to make it the object of a reconnaissance field study.

RAW SILK IN JAPAN

Raw silk plays an overwhelmingly important rôle both in the household economy and in the national economy of Japan. Among the farming population it holds a position second only to that of rice, the universal food crop. Were it not for the profits derived from this subsidiary and auxiliary occupation the Japanese farmers of the lower and middle classes scarcely would be able to maintain themselves. Nearly 2,000,000 out of the 5,500,000 agricultural households in Nippon are engaged in sericulture,[1] the sale of cocoons usually being their single large source of cash income.

In the commercial and financial fabric of the nation silk is scarcely less important, for in the five-year period 1921–1925 raw silk amounted to 39 per cent of the total value of the export trade. So delicate is the adjustment between the silk crop and current prosperity in Japan that a business depression in the United States, which country buys 95 per cent of the exported raw silk, means sympathetic stagnation in Nippon.

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*John Simon Guggenheim Fellow for Geographic Research in the Far East, 1926–1927. The present paper contains the results of one of a series of field studies in the Orient resulting from this fellowship. See "A Geographic Study in Shizuoka Prefecture, Japan," in *Annals Assn. of Amer. Geogrs.*, Vol. 18, 1928, pp. 127–259.

[1] One Thousand Facts about the Raw Silk Industry of Japan, 1927, p. 9. (Published by the Raw Silk Association of Japan.)

Sericulture is practiced in all parts of Japan even as far north as Hokkaido, although in that island and in Aomori, the most northern prefecture of Honshiu, the mulberry acreage, owing partly to the lower temperatures and less rainfall, is small. But from about the fortieth parallel south, mulberry is almost universally grown. Environment can scarcely be invoked, however, to explain Japan's first rank in raw silk production, for there are other regions throughout the world equally favored physically in which not a pound of raw silk is reeled. To be sure, the relatively mild winters and long growing season with high temperatures which prevail over much of the Island Empire are factors conducive to mulberry culture, while the abundance of slope land which is unsuited to paddy rice, and to many of the unirrigated food crops as well, argues in favor of a crop that is tolerant of thin, stony, infertile soils. On the other hand, the physical handicaps are not inconspicuous. Mulberry yields are much less per unit area than they are, for instance, in semi-tropical South China. Late spring frosts at times do serious damage, while the frequently cool, chilly, and erratic weather of April and early May injures the worms. In 1926 the crop of spring cocoons was much reduced because of the abundance of cold rain.[2] The excessively damp and hot weather of the summer months fosters disease among the worms, the crop of 1921 for this reason being almost worthless in places.[3] The prime factor, however, in prospering sericulture in Japan is not environment but rather a too abundant rural population, which finds in the tedious and time-consuming occupation of rearing silkworms a profitable use for excess human energy in perhaps doubling the meager incomes from diminutive farms. It is an adjustment, therefore, to an overcrowded rural condition in a natural environment which in many respects is not unkindly.

Mulberry does not require irrigation, and it is distinctly soil-tolerant, growing fairly well in infertile, thin, acid, or sandy soils, into which it is frequently forced by reason of the severe crop competition prevailing in Nippon. The most extensive and contiguous mulberry acreages are to be found on the mountain foothills, meagerly soil-mantled, bordering the coastal plains or the mountain valleys and on the unirrigated diluvial terrace lands and the coarse-soiled alluvial fans along the inner margins of the coastal plains. Illustrative of the latter site conditions are the large uninterrupted areas of mulberry on the low, level, ash-covered terraces and the steeper bordering fans of the Kwanto or Tokyo Plain. Other common sites for mulberry, although less extensive than those previously mentioned, are the sandy outer margins and old beach ridges of the delta plains, where

[2] *Commerce Yearbook*, 1926, Vol. 2, Foreign Countries, p. 339. U. S. Dept. of Agriculture.

[3] Daniel H. Buchanan: The Rural Economy of Japan, *Quart. Journ. of Economics*, Vol. 27, 1922–23, pp. 545–578.

the growing of irrigated crops is difficult, and the somewhat higher ground adjacent to the elevated and diked streams of the alluvial lands, or the stony soil between the dikes where there is a dual system of protective embankments. It is not entirely absent from the low, level paddy areas on some of the delta plains, where it is occasionally grown on small, artificially elevated patches among the rice fields.

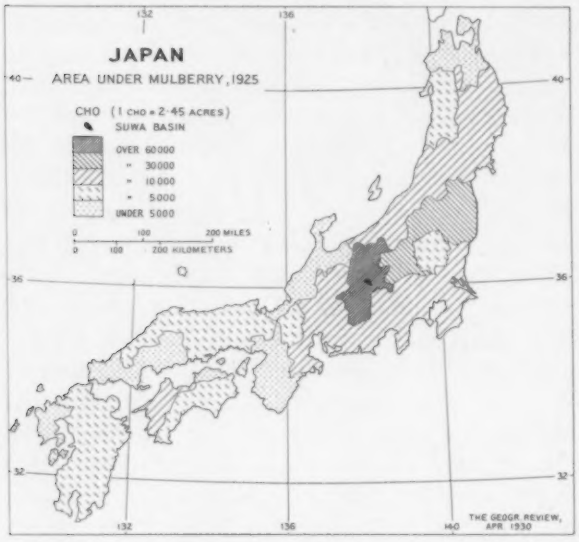

FIG. 2—The distribution of mulberry acreage by prefectures in 1925, showing the outstanding position of Nagano Prefecture (61,444 cho). The Suwa Basin is shown in black.

Within Japan there is a very marked concentration of mulberry acreage and cocoon production in those prefectures that lie within the mountains of central Honshiu. Nagano, an entirely land-locked prefecture, which straddles the crest of the Japanese Alps with drainage both to the east and west, is easily first in mulberry acreage with 11 per cent of the total for the entire country. Its nearest rivals, Fukushima and Gumma prefectures, are likewise of mountainous relief, the latter, like Nagano, having no sea frontage. The concentration of the mulberry crop in Nagano in particular, and only to a slightly less degree in the other neighboring prefectures, reflects in a measure the relative disproportion of suitable rice land and the abundance of slope land. Even the alluvial-floored mountain valleys are likely to have considerable percentages of their areas composed of steeply inclined fans or terraces, usually with coarse-textured, stony soils, so that they are unsatisfactory as sites for rice culture.

Before the railway period the problem of transporting commercial products from the mountains down to the plains was of significant importance, so that a compact and valuable commodity such as raw silk fitted the requirements admirably. In these lands of great relief sericulture is much less of an auxiliary industry than is common throughout most of Japan; here it is more likely to be the chief and even overshadowing occupation.

As the Japanese Archipelago is the focus of raw silk production

for the world, and Nagano Prefecture in turn is the most specialized general region of sericulture within Japan, so the Suwa Graben in Nagano represents the most definite center of raw silk reeling within the country, 12 to 13 per cent of the raw silk of Nippon being reeled within its circumscribed area[4] (Fig. 2).

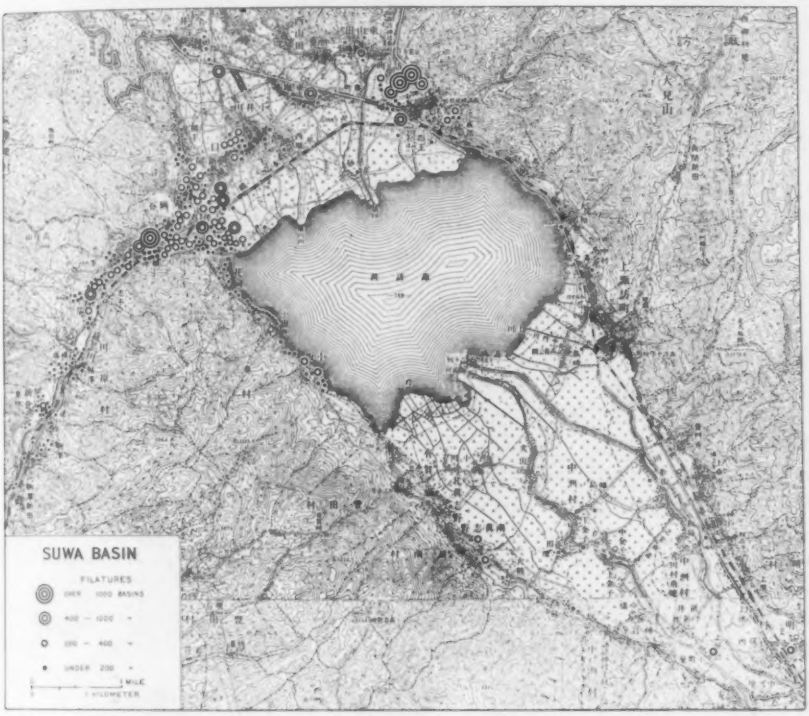

FIG. 3—Filatures of the Suwa Basin. Note the concentration along the Tenryu River. From manuscript map prepared by Katsue Mizawa of Kamisuwa.

THE SUWA BASIN

The Suwa Basin is an alluvial-filled structural depression, ten miles long by three and one half miles wide at its maximum, located in the Japanese Alps of central Honshiu not more than three miles from the crest of the divide which separates the Pacific from the Japan Sea drainage (Fig. 3). High and rugged mountain ramparts, whose lower foothills alone are cultivated, girdle it on all sides except the extreme southeast where the less precipitous slopes of a volcanic cone, together with outlying fans, terminate the already constricted valley. At both ends of the depression the enclosing mountains have been pierced by tunnels in order to allow passage of the trans-island railway line, which uses the Suwa Valley as one link of its route.

[4] Census for Nagano Prefecture, 1925 (in Japanese). Published 1927.

The lowest part of this high-altitude basin, nearly 2500 feet above sea level, is occupied by a shallow lake six to eight square miles in extent, whose outlet is by way of the Tenryu River. On the northwest a steeply inclined delta fan under intensive cultivation in mulberry and rice is encroaching upon the lake margins, while to the southeast a larger delta of much milder gradient, finer-textured soils,

FIG. 4—The lower slopes of Suwa's mountain borderlands are devoted almost exclusively to mulberry; the higher slopes are in woodland and grass. Villages are concentrated at the base of the slopes.

and more exclusively devoted to rice, is making similar trespass. A number of small, diked streams, some of them distributary and intermittent in character, traverse the delta fans and provide the irrigation water for the paddy fields. Numerous small villages dot both alluvial areas and occupy sites along the foothill margins, while several industrial urban communities, specializing in silk reeling, the largest a city of 40,000 people, have developed on the northern fan (Fig. 3).

Contrasts of first magnitude lead to a differentiation of two major geographic units, (1) the Encircling Mountain Foothills, and (2) the Basin Floor. The latter, by reason of morphologic contrasts of lesser magnitude, is further subdivided into three geographic sub-units, (a) the Lake, (b) the Southeastern Delta Fan, and (c) the Northwestern Delta Fan.

THE ENCIRCLING MOUNTAIN FOOTHILLS

The lower slopes of Suwa's mountain borderlands, like those surrounding other densely populated intermontane depressions in central Honshiu, are devoted almost exclusively to mulberry, which is the single article of diet for silkworms (Fig. 4). It is the writer's observa-

tion that throughout Japan uniform cropping on slopes is not usual, but such is the case on the Suwa foothills, where scattered patches of woodland on the more abrupt slopes are the only variation from mulberry. The mulberry patches are tiny affairs, only a fraction of an acre in area and varying in size and shape according to the configuration and angle of slope (Figs. 5 and 6). On the steeper gradients

FIG. 5—Rice fields in the foreground, mulberry on the slope land. Note the almost continuous line of rural habitations along the base of the foothills.

the terraced mulberry fields become strips a few feet wide, following the contours. On milder slopes the fields are unterraced or only roughly terraced. One marvels that slope wash and gullying do not ruin them, although the coarse soils of incompletely weathered andesite no doubt allow a rapid percolation of rain water.

The width of the mulberry zone and the elevation of the upper margin of cultivation are variable, depending largely upon degree of slope, depth of soil cover, and nearness to villages. From 300 to 650 feet above the basin floor is perhaps an average upper limit. The advantage of proximity to villages, whereby the frequent pickings of bulky fresh leaves do not have to be carried long distances, often leads to a heightening and deepening of the mulberry zone in the immediate hinterland of settlements, as for instance back of the city of Kamisuwa.

A very definite landscape pattern is to be observed at irregular intervals along the foothills where narrow alluvial-floored valleys or even gulleys, containing creeks, descend to the basin (Fig. 7). On the floors of these depressions adjacent to the source of irrigation water, and where the slopes are relatively mild, tiny, terraced irrigated rice plots prevail. Flanking the narrow strip of paddy land on either side

and occupying the lower slopes of the valley sides, as well as projecting deep enclaves up the tributary gulleys, is the mulberry zone, while the higher slopes and the stream divides bear a mantle of trees or coarse tawny grasses. The culture cross section is therefore rice, mulberry, and woodland or grass. The smaller valleys contain few or no rural residences, the fields being worked by agriculturists living in settlements that occupy sites on fans around the perimeter of Suwa Basin at the mouths of the ravines. Narrow cart roads follow the tributary depressions for a short distance back into the mountains, so that the valley farms are more accessible than are those on the steeper slopes of 20° to 30° bordering the main basin. This factor of accessibility is reflected in the valuation of the mulberry lands along the foothills, those on the lower slopes adjacent to the villages being priced at $360–$600 per acre and decreasing to $30–$60 per acre along the upper margin of the zone of cultivation.

Above the mulberry zone, woodland and grassland prevail, the grasses being coarse and unnutritious and for the most part unused. The general meagerness of timber on the mountains may possibly be interpreted in terms of an early cotton- and silk-spinning industry, which, before the days of coal, consumed large quantities of charcoal made from the forests on the adjacent mountains. The denudation of the tree cover was not followed by natural or artificial reforestation on a large scale, so that today much of the higher slope land is bare and brown and the charcoal supply is insufficient to meet the local demand, requiring importations from outlying districts.

Mulberry in Nagano Prefecture, reflecting the shorter frost-free period in these altitudes, is an early-budding, quick-maturing, dwarf variety of bush. The growing season at Matsumoto, not far from Suwa and nearly 600 feet lower, is only slightly over five months as compared with seven months and eight days at Tokyo in the Kwanto Plain near sea level. Compensating for this advantage of early budding and quick maturing is the accompanying disadvantage of small yield of leaf, estimated at 30 per cent less per unit area as compared with the bushes of Kwanto where larger, longer-maturing, more prolific varieties are grown.[5] In the latter lowland, where the growing season is longer, temperatures higher, and rainfall heavier, bushes are able to produce one major crop of leaves together with a later minor picking; but one picking is usually the limit in the mountains.

In these elevated valleys of Nagano late spring frosts are a very genuine hazard for mulberry, doing some injury almost every year. On May 12, 1927, just a few days before the writer arrived at Suwa, a severe frost did serious damage to spring mulberry throughout the mountain area of central Honshiu. The *Japan Advertiser* on May 15

[5] Information obtained at Sericultural Experiment Station, Nagano.

carried a news item to the effect that Nagano alone had suffered a loss of 3,000,000 yen[6] as a result. More than 75,000 acres were affected in that prefecture, and it was estimated that the crop of silkworms would be reduced 30 per cent. It was considered such a catastrophe that government assistance for the stricken farmers was to be requested. While frost damage of this magnitude is not frequent, some

FIG. 6—Terraced mulberry patches. In some fields the mulberry is in leaf; in others it has been cut down close to the ground. The former will furnish leaves for the spring worms, the latter for the summer and autumn worms.

degree of injury is ordinarily so probable that the farmers of this region have been persuaded to specialize in summer and autumn worms rather than in the spring crop which is more popular over the nation as a whole.

The mulberry that provides leaves for the spring worm is usually a small, spindling shoot two to four feet high, the entire branch being cut off near the ground and placed in the trays with the adult worms. The small, fragile branches do no injury to the delicate creatures; and the unplucked leaves remain fresh and turgid for a longer period of time. The spring leaves are therefore from the unpruned stems of the previous season. A somewhat taller, coarser shoot is frequently grown to provide leaves for the summer and autumn worms. The latter plants are pruned close to the ground in the spring, the new stems bearing leaves later in the season. By their pruned or unpruned nature in the spring one is able therefore to distinguish in

[6] One yen is approximately 50 cents, American money.

the field the plots destined for spring or for autumn and summer use (Fig. 6). In the Suwa Basin in May the pruned patches appeared to be considerably more numerous, this observation bearing out the previously stated fact, based upon statistical data, that the spring crop of worms is less important in Nagano. The tender new shoots

FIG. 7—Rice occupies the bottom lands and mulberry the lower slopes of the gulches which descend to the lake. Villages frequently occupy sites on the fans at the mouths of the gulches.

of the unpruned bushes were frequently withered and brown, having been frost-killed.

LAKE SUWA

Lake Suwa appears to be a remnant of a once more extensive body of water that has been constricted and shallowed by advancing delta fans so that its present maximum depth is only 24 feet. Some ice is cut from its surface in winter and stored for summer use by commercial ice companies in the cities along its shores. Its waters are utilized in large quantities by the filature plants concentrated along its northern and western margins. The lake itself, by its beautiful setting amidst mountain scenery, has helped to attract a tourist and resort trade to the basin, centering principally at Kamisuwa.

But the chief contribution of a direct monetary nature which it makes to the inhabitants of Suwa is through the fish catch, which annually amounts to $240,000, consisting for the most part of carp, trout, prawn, and eel. Of the 1333 licensed fishermen on Suwa Lake, 1188 are designated as part-time fishermen only,[7] which may be interpreted

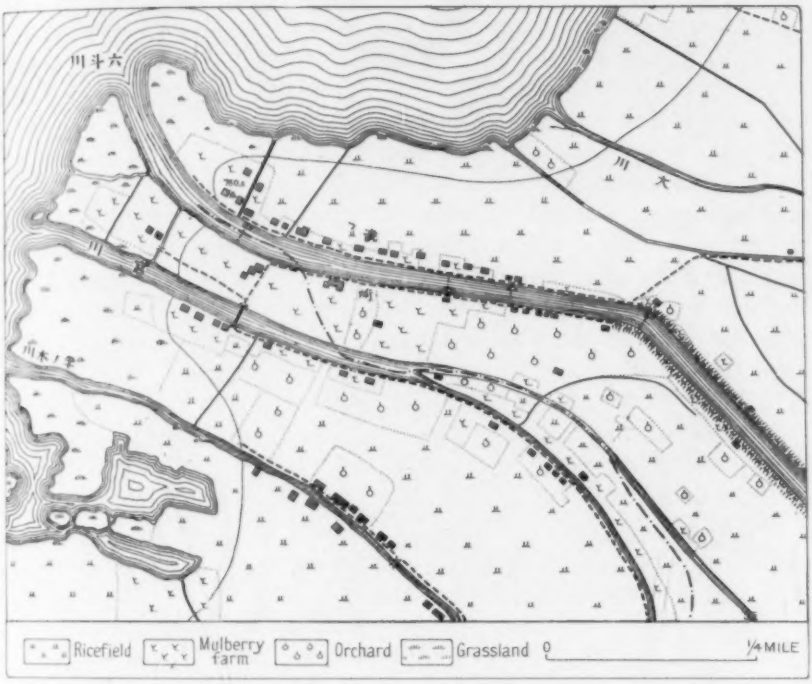

FIG. 8—The lower delta of the two streams that have formed the Southeastern Delta Fan. The fishing village of Shibusaki is strung along the stream channels. Unirrigated crops such as mulberry, orchards, and vegetables compete with rice on the somewhat more elevated lands with sandy soils.

to mean that they are probably farmers who make fishing an auxiliary occupation (Fig. 13). Flat-bottomed fishing scows are numerous on the lake, while, scattered throughout the more shallow waters, poles project above the surface, marking the location of fish traps on the bottom.

THE SOUTHEASTERN DELTA FAN

This wedge-shaped area of alluvium, some five miles long by two and a half or three miles wide at its base where it fronts upon the lake, averages only four to five feet per mile in gradient. Its flat surface is devoted almost exclusively to the cultivation of irrigated rice, the grid or mosaic of paddy fields, with the individual plots irregular in outline, of tennis-court dimensions, and each encom-

[7] Data from office of Fish Association of Suwa Lake in Kamisuwa.

passed by diminutive dikes, being typical of delta-plain landscape everywhere in Japan (Fig. 14). The rice fields produce only the one crop and are allowed to lie fallow during the winter, except that some are sown to genge, a legume which is plowed under for green manure. On the delta plains of lower altitudes many of the paddies are drained in late autumn after the rice harvest and sown to winter wheat or barley. On this southern delta of the Suwa Basin not only is it difficult adequately to drain the water-logged paddies for winter crops, but the alternate freezing and thawing of the wet soils during the relatively long and severe winters causes the grain plants to be lifted out of the ground and their roots injured.

Two small streams, which have largely formed the delta fan, cross it in elevated and diked channels throughout its entire length. They are conspicuous features on the plain because of the man-constructed embankments, several meters high, that enclose them and prevent inundation and destruction of the valuable paddy lands, which are somewhat lower in elevation than the streams (Fig. 11). Here, therefore, one ascends rather than descends to the river channels. Unnavigable except for flat-bottomed scows along their extreme lower courses, these streams are indispensable since they provide the irrigation waters for the rice fields, their raised channels making a simple gravity system of irrigation possible. Footpaths or even narrow cart roads follow the crests of the dikes, while in places lines of rural residences likewise occupy the higher and better-drained sites adjacent to the stream channels. Approaching the lake the two streams are flowing in parallel channels not more than an eighth or a quarter of a mile apart (Fig. 8). Here there is a very perceptible downstream swing of the 760-meter contour; and this, together with the item of coarser soils, is perhaps explanatory of the considerable acreage of unirrigated crops, more especially mulberry and deciduous orchards (apple, peach, and Chinese quince) that modify the general paddy-field landscape of the delta in these particular locations. The inhabitants of the tiny village of Shibusaki which is strung out along the lower channels of the rivers have made fishing their major occupation as the numerous flat-bottomed scows drawn up along the river banks, fish boxes, and scores of nets proclaim.

The rural villages tend to concentrate around the margins of the valley at the base of the foothills and more particularly on the tiny alluvial fans at the mouths of the gullies and ravines (Fig. 7). Here the land is higher and drier than farther out on the plain, while it has the additional advantage of being intermediate in position between the cultivated slopes in mulberry and the irrigated paddies on the alluvium. Fan sites are further desirable because, being at the mouths of valleys, they have more extensive and easily accessible hinterlands. In those sections of coast along the northeast and

southwest margins of the lake where the mountain foothills approach very close to the water's edge almost every fan has a village, and where there are no fans there are no villages. From across the lake the location of the fans can be easily detected at night by the clusters of village lights. The street patterns are frequently adjusted to the configuration of the fans, one set following the concentric trend of the contours while a second set is distributary in form, crossing the former at right angles (Fig. 7). Unirrigated vegetable plots immediately surround many of the village homes on the fans, but mulberry is the premier crop on these elevated coarse-soiled deposits where slope and soil make paddy-field development difficult.

The two major highways of the Southeastern Delta Fan, like the villages and for the same reason, follow the outer margins of the basin adjacent to the foothills (Fig. 3). Minor transverse roads, along which have collected lines and clusters of rural residences, cross the delta between the two highways. Kamisuwa, of 17,000 population and the one city of consequence on this alluvial area, is an old castle

FIG. 9

FIG. 10

FIG. 11

FIG. 9—Mulberry on the upper slopes of the northwestern delta fan of steeper gradient and stony soils. Smokestacks of filatures farther down the fan.

FIG. 10—Orchard of Chinese quince with rice on inundated sections between individual trees. Lower slopes of the northwestern delta fan.

FIG. 11—A diked stream on the lower part of the delta fan; paddy fields below. The crest of the dike is used as a cart road.

town, its earlier growth and importance no doubt being associated with this fame. It is now a railway city of some importance serving as the receiving and distributing center for the south delta. Hot mineral springs together with the scenic effect of lake and mountains have combined to make Kamisuwa something of a resort city. High-class, attractive inns with hot sulphur baths cater to a transient type of tourist trade especially in winter when skating on Lake Suwa is a great attraction. Elsewhere in the Suwa Basin the hostels are mediocre if not actually undesirable, so that Kamisuwa has become the hotel center for the entire area.

The Northwestern Delta Fan

This alluvial deposit is much more of a fan and less of a delta than its counterpart on the opposite side of the lake (Fig. 12). A geographic cross section two miles long from the apex to the base of the fan exhibits contrasts in slope, soil, and culture forms. Toward the head, where the gradient is 125 to 150 feet per mile and the soils are exceedingly coarse and stony (Fig. 9), mulberry prevails; but the lower half or two-thirds, where the gradient is only one-third as great and the soils much less coarse, is in paddy fields, some of them terraced. The two or three small diked streams (Fig. 11) that descend the fan are intermittent in character, frequently carrying little water during the midsummer; and the lack of water, added to the difficulty of leveling fields on the higher slopes and retaining standing water on the coarse soils, argues against a more widespread cultivation of rice. Only along the stream courses, and again on the lower flanks of the fan where it makes contact with the mountain foothills and there is an added supply of water from the slopes, does irrigated rice ascend to its crest.

Scattered here and there among the paddies toward the base of the fan are numerous small patches of deciduous orchards, almost exclusively Chinese quince, apple, and peach, with the last of relatively greater importance. In a few spots they dominate the landscape of the plain, but that is not the usual situation. As they are likely to be surrounded with the wet paddy lands, either the whole orchard plot or the individual trees are on artificially elevated and drier ground (Fig. 10). In some orchards rice is intercultured with the trees. The fruit is entirely for local consumption, the peaches and apples being used in the fresh state while the quince are preserved and sold in the near-by city markets. Late spring frosts make fruit growing a hazardous occupation; and in May, 1927, the writer found the peach crop an entire failure.

Human life is more abundant in this northern delta fan than in the one to the south, the result of a more complete industrialization. Okaya, with a permanent population of 40,000 and with 30,000 addi-

tional female workers in the silk-reeling mills during nine months of the year, is located on a strategic site at the southwestern angle of the delta where the Tenryu, outletting from Lake Suwa, pierces the mountain wall, its valley being followed by the trans-island railway

FIG. 12—The Northwestern Delta Fan. The steeper, stonier upper part of the fan is planted chiefly to mulberry while rice occupies the lower sections with milder gradients. The city of Okaya is at the southwest angle of the fan.

which traverses the basin. This city is the focus of the silk-reeling industry for all of Japan. It is quite as unattractive as it is industrial, its slatternly buildings and streets suggesting anything but prosperity, but nevertheless being rather typical of manufactural towns. Shimosuwa, a city of nearly 16,000 people on the opposite angle of the fan, is in most respects a replica of its larger neighbor.

THE SILK INDUSTRY: HISTORICAL SETTING

That the writer has chosen to develop topically certain aspects of raw silk production that are common to the industry as a whole, under the regional heading of the Northwestern Delta Fan merely reflects the paramount rank of that locality in silk reeling.

On first thought it strikes one as an anomaly that the processing center of an empire's most important item of export should be located in a secluded mountain basin such as Suwa, far removed from the great centers of population, industry, and commerce. Very definitely the concentration of 12 to 13 per cent of the nation's filatures in Suwa is related to its situation in the midst of an area thoroughly

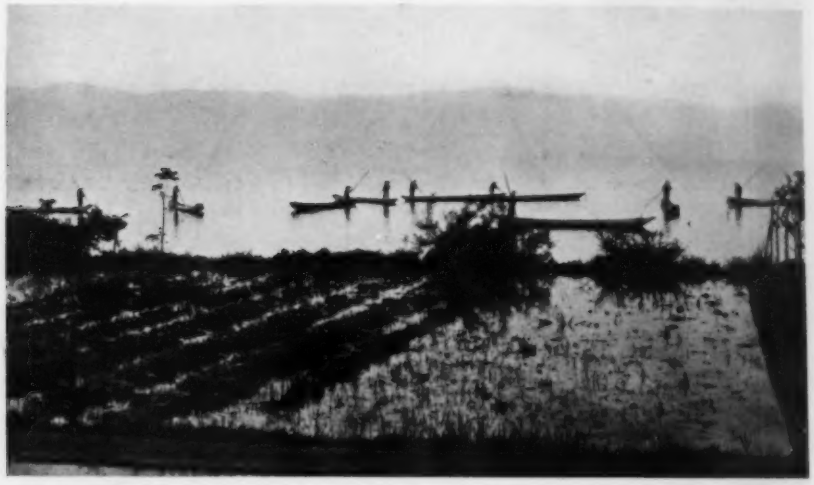

FIG. 13—Fishermen on Lake Suwa. Such a village as Shibusaki (Fig. 8) also obtains part of its catch from the streams.

specialized in cocoon production. The specific localization of reeling at Suwa, however, can only be interpreted by reconstructing the earlier history of the area.

Before 1750 the inhabitants of Suwa were engaged almost exclusively in agriculture.[8] At a still earlier period cattle breeding had been of some consequence in the northern delta, but increasing density of population had made it uneconomical. About the middle of the eighteenth century a new development first made its appearance when the crude processing, on a commercial scale, of cotton and silk fibers was inaugurated. Suwa, lying between the cotton-producing plains of the south Pacific coast of Japan and the non-producing west and northwest, at a natural sag in the dividing range, and near the heads of a number of radial valleys which ascend from the Pacific coast, became a relaying and distributing center. The raw cotton from the southeastern lowlands was halted sufficiently long at Suwa to be cleaned and crudely processed before being sent on to the northwest. Most of the cotton and silk dealers were agriculturists as

[8] Information concerning the historical geography of Suwa Basin has been obtained from Katsue Mizawa of Kamisuwa, both through personal conferences and from his published paper, "The History of the Suwa Silk Industry, from the Geographical Viewpoint" [in Japanese] in the *Geographical Review of Japan*, Vol. 2, No. 10, October, 1926.

well, devoting their time and energies to farming and some silk reeling in summer, the cotton industry being more of a winter occupation when the relatively severe weather makes out-of-door work unpleasant. An auxiliary industry and source of income was very desirable to the agriculturists of these high altitudes where rice cultivation is less profitable and winter crops are lacking.

FIG. 14—Typical delta fan landscape in spring after the young rice plants have been transplanted.

But some time after the opening of Japan to foreign trade in 1853, cheap raw cotton from outside led to a displacement of the native product, so that Suwa gradually lost its position as a cotton-distributing and processing center. But as the cotton industry declined the capital and labor which it had employed were shunted over to silk spinning, giving it a new impetus. In 1886 Hirano village in the northern delta had 50 citizens who were engaged exclusively in silk reeling. An investigation of their previous occupations showed that 25 of them had at some earlier time been cotton dealers. Their filature plants at this time were small affairs to be sure, but machines operated by foot, hand, or water power were in common use.

Marked concentration of filatures at Okaya did not take place until after 1885 or 1890. Mizawa points out that those scattered villages which had been the earlier centers for cotton processing were naturally the first to develop silk spinning on a relatively large scale, and so the industry was at first geographically decentralized. Those villages near large supplies of timber which could furnish the necessary fuel for the filatures were also happily situated for attracting, at an early period, the location of spinning establishments; and in this respect many villages were better off than was Okaya.

But, as the number of factories increased and the earlier estab-

lishments expanded, there arose the problem of finding new factory sites. The banks of the Tenryu at this time became particularly attractive, for here was cheap land, water, and available power from the river; and this last item became increasingly more important as the industry evolved from home to factory dimensions. When the railroad was built through the basin, with exit to the northwest by way of the Tenryu Valley, Okaya claimed another advantage (Fig. 3).

Cocoon Production

In Suwa, as in the rest of Japan, three main crops of cocoons are recognized—a spring, summer, and autumn yield. The limited number of hatchings is largely determined by the variety of mulberry prevalent, which is the true *Morus alba* of middle latitudes and is not nearly so prolific a leaf producer as is the tropical variety of mulberry common in South China, which yields a constant supply of leaves from February until November and supports as many as seven generations of silkworms.[9] Two crops of leaves, the later a minor one, are usually the limit for the Japanese mulberry.

The spring worms in Japan are a univoltine breed, producing only one brood a year. In Nagano Prefecture the hatching occurs in late May, a month later than in warmer Kwanto. Partly, if not largely, because of the late frosts and cold springs which are injurious to mulberry and to the sensitive worms alike, the spring crop of cocoons in Nagano amounts to only 40 per cent of the total for the year, while for the country as a whole spring cocoons compose 57 per cent of the crop. They yield the highest quality silk, the strands being longer, thicker, and more uniform in diameter than is true for the hot-season product. The summer and autumn cocoons are spun by univoltine and bivoltine worms hatched in early July and early August. The current weather has much to do with the health of the worms and the quality of cocoons they spin.

Silk Reeling

Nagano produces nearly twice as many cocoons as any other prefecture, or 13 per cent of the total for the whole country; but its position as a reeling center is even more marked, 27 per cent of the raw silk of Japan, valued at 256,000,000 yen,[10] being spun by its factories. This is more than three times the value of filature products of any other prefecture and is clearly indicative that the industry has outgrown its immediate surroundings as a source of cocoon supply. Nearly one half (47 per cent) of the total raw silk reeled in

[9] C. W. Howard and K. P. Buswell: A Survey of the Silk Industry of South China, *Lingnan Agricultural College, Agric. Bull. No. 12*, [Canton, China,] Jan., 1925, p. 42.

[10] Annual Report of the Department of Agriculture and Forestry, 1925, Tokyo.

FIG. 15

FIG. 16

FIG. 15—Okaya in the heart of Japan's mulberry and cocoon-producing district and the greatest center of silk reeling in the Empire.

FIG. 16—The Katatura filature occupies a favorable site on the banks of the Tenryu River.

Nagano is concentrated in Suwa Gun and almost exclusively in the northern delta fan of the Suwa Basin with Okaya, and to a much less degree Shimosuwa, as the major centers.

The historical antecedents of the present reeling industry at Suwa have been previously suggested. It has been previously emphasized that the basin lies near the center of Japan's greatest cocoon-producing region with the advantage that the situation has to offer in large the adjacent supplies of raw materials for the factories. In the cooler, drier atmosphere of the mountain basin[11] cocoons are more easily and safely stored without serious danger of spoiling. The same climatic condition operates to facilitate the reeling and rereeling processes. The use of moisture-proof steel containers for the cocoons in many storage houses and the artificial control of atmospheric humidity in the factories make the climatic factor much less critical at the present time, but itwas of more serious consequence at an earlier period. The abundance of water free from injurious alkali salts and iron and easily available from the lake, the Tenryu River, and fan gravels has been a positive factor. Filatures consume an enormous amount of water, estimated at about 65 gallons per basin per day, the 37,400 basins of Suwa requiring therefore nearly 2,500,000 gallons daily. The presence of calcium or magnesium in the water tends to harden the sericine covering of the silk fibers and cause them to lose their luster, while the presence of iron tends to discolor the fibers. Adjacent to all the filatures are large open tanks in which the water after being mechanically filtered is slowly circulated before use, that the calcium, magnesium, and iron may be precipitated by exposure to sunlight.

It is the writer's opinion, corroborated by the testimony of factory managers, that inertia has carried filature concentration in Suwa Basin beyond the point of economic desirability. The environmental set-up which characterizes the graben is by no means exclusive to that region or even to Nagano; and, moreover, with the present ability to regulate indoor climates and to precipitate injurious compounds from water by chemical means the filature industry is not oversensitive to those elements of the natural environment and might well be concentrated in conformity with the cocoon supply. The reeled silk is such a concentrated and valuable commodity that its cost of transportation would be small compared with that of cocoons. As a result of focusing 12 to 13 per cent of the nation's filatures at Suwa, the competition for cocoons in the surrounding countryside has become injurious and the supply must be brought from relatively great distances. The manager of the Katakura filatures in

[11] Matsumato, near Suwa, has 46 inches of rain compared with 63 at Tokyo and 80 at Numadzu, while the summer temperature at Matsumato is 4.5 lower than at Tokyo with lower absolute and relative humidity.

Okaya estimated that 85 per cent of the cocoons for their four plants in that city came from outside of Nagano Prefecture. A high and unnecessary toll is thereby paid to the railways in transporting this bulky and relatively cheap freight and in returning the empty baskets.

The writer was unable to secure reliable published data indicating what proportion of Suwa's silk is reeled at Okaya, but factory managers estimated it at about 90 per cent. The low, rambling, cheaply constructed frame and plaster buildings which house the reeling industry are not distinctly obvious to the eye as one gazes down upon the city from the surrounding hills; but their locations are unmistakably marked by the scores of tall steel smokestacks which rise from 50 to 100 feet above them, giving a distinctly industrial sky line to the city (Fig. 15). Although imported electric power is used by most of the plants for driving the machinery, coal as fuel is still used in heating water for the basins, stifling the cocoons and controlling the temperature and humidity inside the factories. Because of their cheap and flimsy construction, without adequate provision for heating in cold weather, the filatures are closed during the two or three winter months.

The other very obvious landscape feature in the city is the huge cocoon warehouses, five to six stories high, with a long continuous battery of open windows encircling each story and allowing a free circulation of air through the storehouse (Fig. 15). Wide eaves project several feet beyond the sides of the building above each row of windows and protect the interior from rain and too much sun. These buildings likewise are of cheap and flimsy construction, usually mud-plaster whitewashed, supported on a skeleton framework of light timbers. By all odds the most pretentious building in the city is the enormous concrete, brick, and steel cocoon warehouse of the Suwa Warehouse Company. The building covers an area of some 66,000 square feet, with storage floor space of 110,000 square feet.[12] The warehouse not only affords storage service but it is an important cog in the financing machinery as well. Cocoons are distinctly seasonal in their production, while the reeling mills operate from nine to ten months of the year. Thus large quantities of cocoons must be purchased in summer and fall and put into storage in order to supply the plants throughout their operating season. Moreover, cocoons must be subjected to high temperatures within two to three weeks after the worm has finished spinning, in order to kill the moth inside and prevent its boring through. Not only is it difficult for the spinning company to muster enough ready money to pay cash for the cocoons, but there is also the loss sustained through having so much idle money tied up in the stored product. Warehouse receipts issued by the Suwa Company

[12] Complete Plants of Drying and Storing of The Suwa Soko Kabushiki Kaisha (The Suwa Warehouse Co., Ltd.), Okaya, Nagano Ken.

are accepted by the Bank of Japan as security on loans up to 65 or 75 per cent of the value of the stored cocoons. With this credit more money is available for cocoon purchases.

Within Okaya there is a distinct preference for filature sites along the Tenryu where water and direct power are most easily obtained and waste disposed of (Fig. 16). This location is not now as critical since imported hydro-electric power has come into common use by the industrial plants. Filatures located back some distance from the river or the lake are compelled to pump their water from underground sources, the supply of ground water in the fan gravels being abundant and usually not more than nine to ten feet below the surface (Fig. 19).

The rereeled silk from the Okaya filatures is twisted into skeins, which are packed 30 in a bale or "book" and shipped to Yokohama for export abroad. All silk goes through the government conditioning house at the port, where it is weighed and accordingly given a government rating. The new conditioning house at Yokohama, completed in 1926 at a cost of 5,000,000 yen is an imposing building with a floor space of ten acres. Connected with the conditioning house are four large and modern warehouses for raw silk storage. Between 75 and 80 per cent of Japan's silk is exported, 95 per cent of these oversea shipments going to the United States. Yokohama is the leading silk port, handling 80 to 90 per cent of the foreign shipments, Kobe taking the remainder. Up until 1923 when the great earthquake demolished Yokohama, that port handled the entire silk export. As a result of Yokohama's misfortune Kobe began to participate in the trade. The remarkable development of the raw silk industry in western and southern Japan, which region is naturally tributary to Kobe rather than to Yokohama, has been a further reason for that city's being able to retain a share of the silk exporting business.

THE CONFLENT: A STUDY IN MOUNTAIN GEOGRAPHY

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Ohio State University

THE Conflent, at the eastern end of the Pyrenees, is the territory of the streams confluent to the River Têt which, paralleling the mountains, meets the sea at Perpignan. The area is a rectangle some 40 kilometers northeast by southwest and 20 kilometers wide. The northern half is of schistose foothills, continuations of the mountain spurs, and of the intervening valleys. The southern portion is in the granitic core of the Pyrenees. The valleys here are glacial gorges. The faceted spurs of the mountains indicate a fault face. The line between foothill economy and that of the mountain is as sharp as is the fault line. The area includes a well known peak, Mt. Canigou, which stands out from the range and dominates the plain to the east. This is the plain of Roussillon, a fertile coastal area devoted almost entirely to vines. There is as transition a foothill zone, known as the Aspres, which is given over largely to the cork oak and in lesser extent to the olive. On the south is Spain, climatically different. To the west lies the high-level French Cerdagne, a plateau sloping without break into Spain. The northern limit is the valley of the Têt whose far flank is formed by the Massif de Madrés, a relatively barren country.

Climatically the Conflent is in the zone of transition between the Mediterranean climate and that of southwestern France. Approximately the temperatures are Mediterranean while the storm control and precipitation are characteristic of continental mountains. Perpignan on the Roussillon plain has a winter maximum of rainfall; Mont Louis at the western edge of the Conflent has a secondary summer maximum; Vernet-les-Bains has a true continental summer maximum. The region slopes from the crest of the Pyrenees on the south to the valley of the Têt on the north. The cork oak and the olive grow at the gates of the region. Ascending, one soon leaves the heat and dust of the French Midi. The evergreen oak and a deciduous forest are succeeded by hemlock, beech, and mountain pine; streams are cool and snow-fed; and there is a freshness to the air the more delightful for the contrast with the heat of the plain. Above the forest there are alpine meadows. The tree line is at about 2200 meters. Mt. Canigou has snow nine months of the year and in a cirque holds a small permanent snow field.

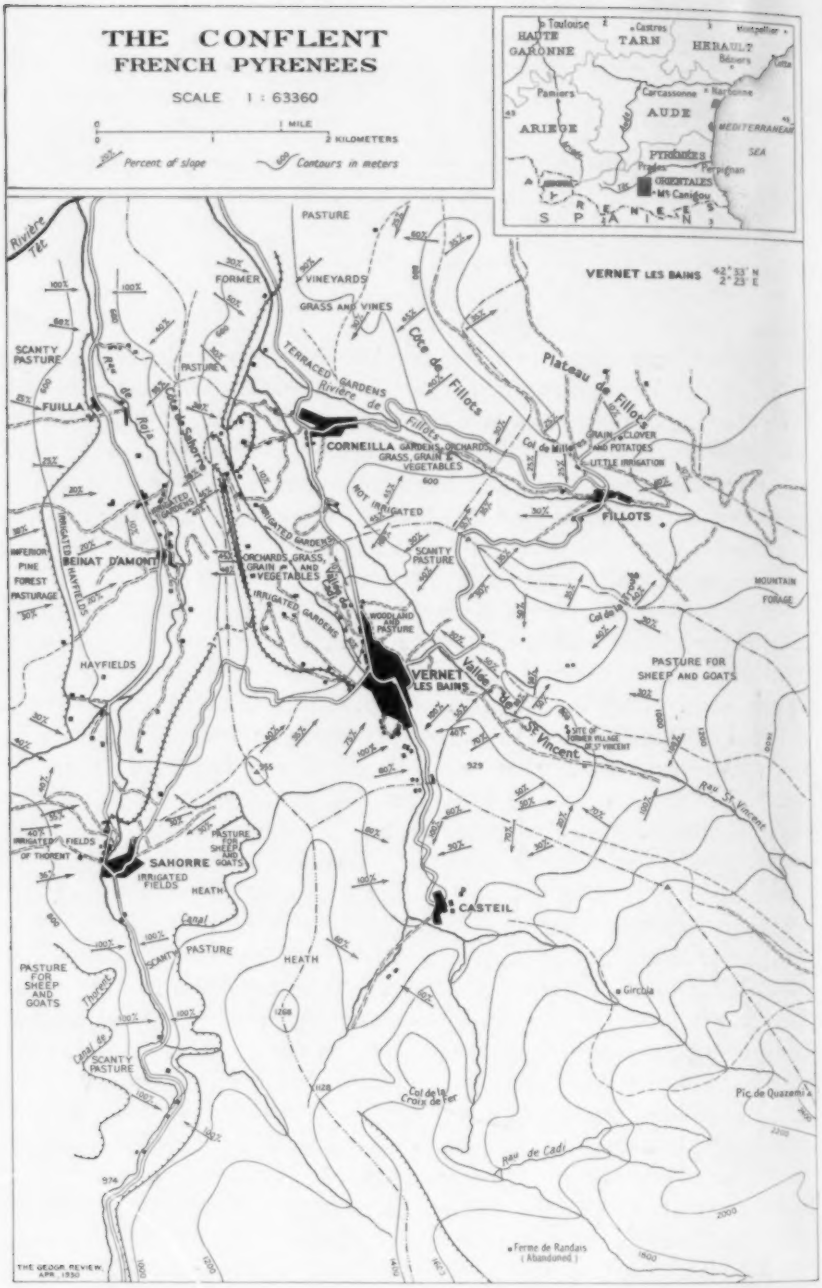

FIG. 1—Map of the Conflent showing contours at 200-meter interval and direction and percentage of slope (45° = 100 per cent). The inset, showing location of the area mapped, is on a scale of approximately 1 : 5,000,000.

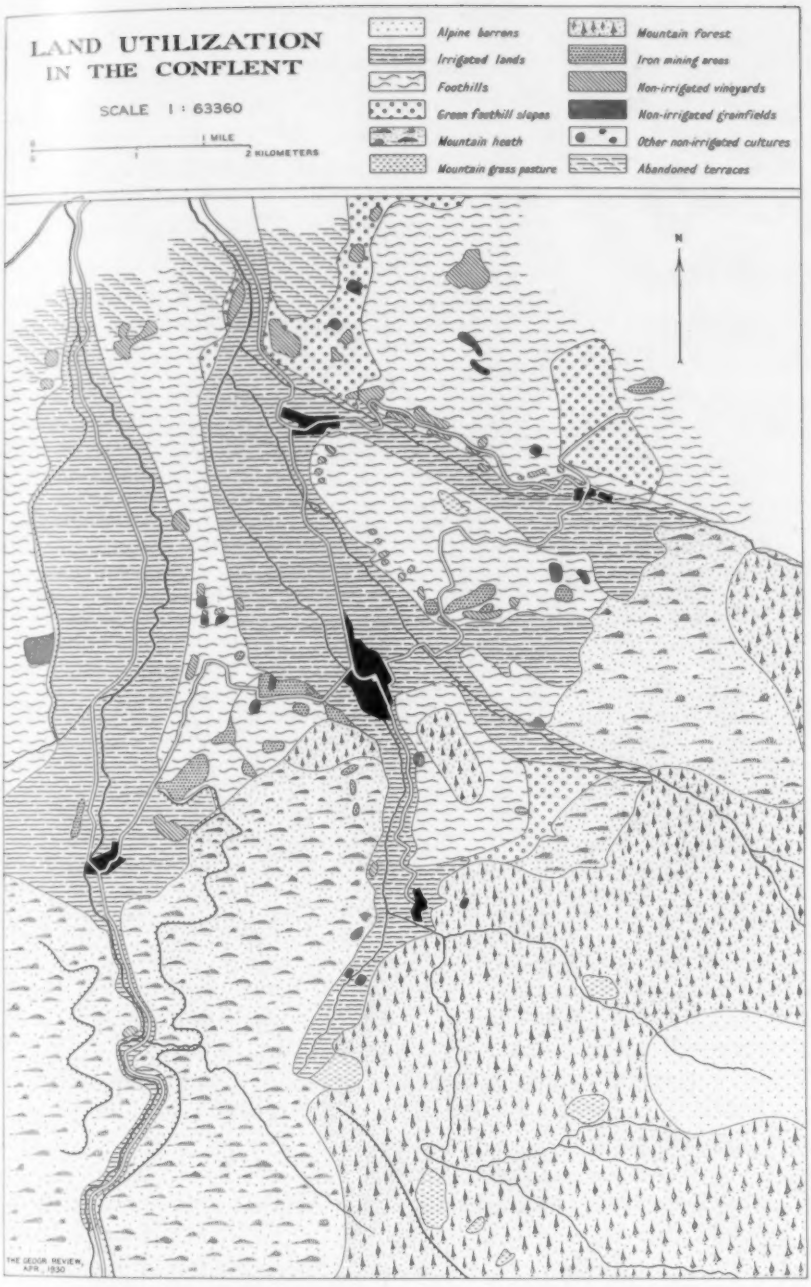

FIG. 2—Map of the Conflent showing the various types of land utilization. Figures 1 and 2 were combined in the field map, which was in color and on a scale of 1 : 12,500.

Method of Study

This treatment of regional geography has a two-fold purpose. First, the study was made in the process of collecting data to the end of determining a set of principles of mountain geography. Second, a test was made of the value of land-utilization mapping in regional geography in mountains. To the writer the value of a land utilization map lies in its revelation of the character of an area rather than as an inventory. The procedure was to select a characteristic portion of the Conflent, map it, and cease operations when conditions of land use began to repeat themselves. The economic *motif* of the region was sought, rather than statistical data. The portion mapped (Figs. 1 and 2) is of the valleys of Fillols, Vernet-les-Bains, and Sahorre—all tributary to the town of Villefranche in the Têt Valley. The area is some 60 square kilometers. One region, the valley bottom land, had a particular organization. This called for a second and detailed map showing size, shape, and use of fields (Fig. 3). When this mapping threatened monotony, it was considered completed. There was one type of field, or rather garden, that required even greater detail and a third map (Fig. 4). Though the Conflent is far from completely mapped, yet these three maps are offered as sufficient graphic data for understanding the character of the region. In addition, the first map is an experiment in the cartographic expression of material pertinent to principles of mountain geography.

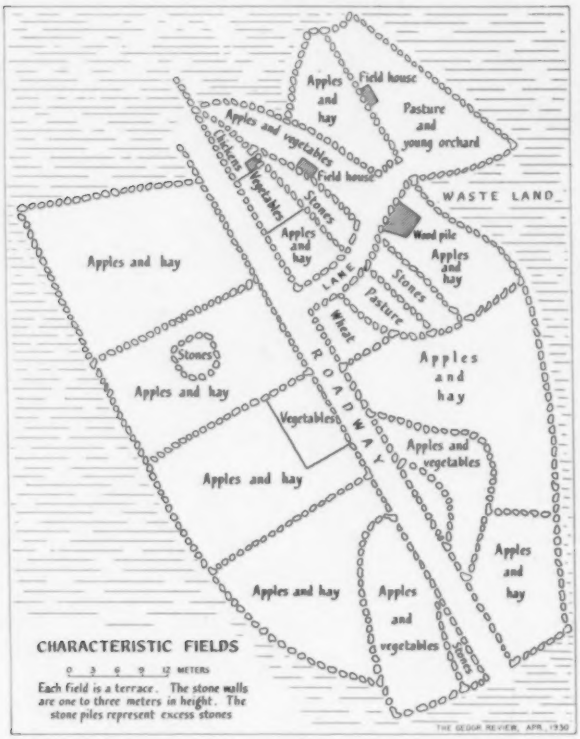

Fig. 3—Map of typical fields in the Conflent.

In the region there are six types of human-use areas; valley bottoms, foothills, mountain pastures for goats and sheep, forests, mountain pastures for cattle, and alpine barrens. These were deline-

ated. As there exist here no fine distinctions as to climatic-height limits of fields, numerous contours were not necessary. In the interest of map simplicity a 200-meter interval was selected. The contours were adapted from the standard government map (1:200,000). Degree and direction of slope were in their details highly important. Such were shown with an arrow marked with per cent of slope. Per cent of slope was used in preference to degree of slope, as 100 per cent slope (45 degrees) marks the limit for even terrace culture. On the other hand, small beasts will pasture and trees will grow on anything short of a precipice.

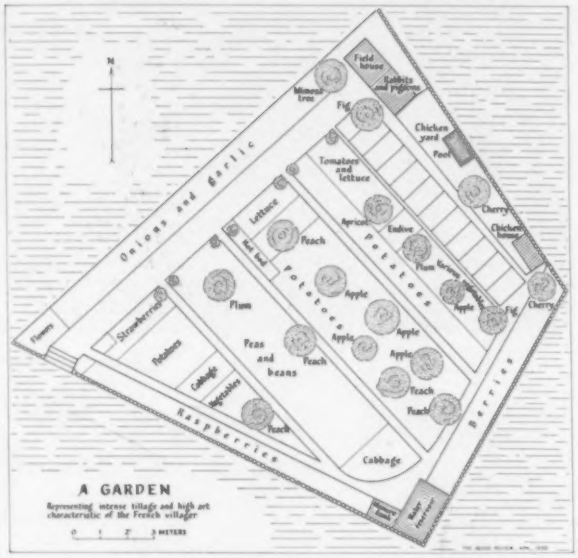

FIG. 4—Map of the garden of Capitaine Alexandre.

THE VALLEY BOTTOMS

The valley bottoms have little width in the mountain zone but widen significantly among the foothills. They are filled with valley trains which have been terraced by the streams. Close to the center of glacial action, the trains were to no small extent of cobbles and boulders; but both surface and character of the soil have been greatly modified by man. Eighty per cent of the land is in formal terraces retained by walls of glacial cobbles. So largely have cobbles been collected from the land that the scythe is used in the fields without danger. Great piles of excess stones stand about, reducing the tillable acreage. Whereas the original soil could not have been of the best, today after centuries of manuring, irrigation, and grass growing, the humus content is high. Though agriculture is possible without irrigation, the rather significantly large production of the region is due to it. Hay, for winter feeding of the beasts descending from the mountains, is the main burden of the fields. Field crops for stock are likewise important. Garden truck and grains complete the list. Grains have declined on the valley lands, though still grown extensively on the foothills. Flour is now imported. The millers complain that they no longer have grain to grind; the mill wheels are still. Transportation facilities have increased, and the community has found a money

FIG. 5

FIG. 6

FIG. 5—Vernet-les-Bains lies at the upper end of its basin and at the foot of Mt. Canigou. The fault face of the eastern Pyrenees lies between the foothills shown in the picture and the mountains.
FIG. 6—There is a sharp contrast between the dry foothills and the irrigated valley bottoms.

FIG. 7

FIG. 8

FIG. 7—The *Jasse de Mariailles* is on a spur of the main crest of the Pyrenees. Here cattle find summer pasture.

FIG. 8—The mountain pine represents the last tree zone as one ascends Mt. Canigou. In the cirque bottom is a *jasse*. Elsewhere there is a scanty forage among the rhododendrons.

crop in apples, which are now grown for the Paris market. The apple does not detract from the acreage devoted to grass or vegetables, as the orchard lands bear these other crops in the shade of the trees.

Fields and Gardens

There are no statistics upon the size of fields or holdings. The accompanying map of fields is typical (Fig. 3). The fields are small

Fig. 9—In the valley bottoms grass and apples are the common crops. Excess stones are piled in the midst of the fields. The thicket in the background marks the course of an irrigation ditch.

and even tiny. The steeper the slope and the greater the number of original surface stones, the smaller the field. The size of the fields and time-honored tradition have imposed upon the cultivator a lowly hand labor. The vegetables are planted and cultivated by hand. The grass is cut with the scythe and carried to the village on the back. A man fairly buried in a staggering load trots a kilometer to the village grange. The cultivation of the land, the tending of the ditches, and the digging of potatoes are all accomplished with a short-handled mattock. The worker stands with legs far apart and body bent far forward.

The character of French agriculture in general and of the Conflent in particular reaches its epitome in the family garden. It is not necessarily the house garden, as with us, but may be one of the fields. It is frequently dignified with a cemented stone wall and an iron gate. The garden itself is planned and worked with a finesse that gives a cabbage patch an aspect of beauty. It represents a high art of agriculture. The orderliness practiced here is reflected in all the fields.

The third map represents an actual example (Fig. 4). This is the *jardin* of Capitaine Alexandre, five minutes' walk from his house. The area was less than 400 square meters. The year's vegetables for the family table were well supplied, as were the fruits. The tool house had a pen for rabbits and chickens. The chicken yard was shaded by a cherry tree. Peach, apricot, plum, apple, and fig trees warded off the summer sun from the closely planted vegetables. The vegetables were of many varieties but characteristically French; potatoes were

FIG. 10—The villages are characteristically built about a square and a fountain.

given the most ground. The walls were lined with berry bushes or roses. The corners of the plots were marked with currants and gooseberries. There was no waste space. Farming in the Conflent is intensive gardening.

FOOTHILLS

The foothills are of quartose schist and are dry. Their soil is baked and tawny in color after an hour of sunshine. For the most part the land is worthless. In places there exists a meager stand of an inferior pine, Pin Laricio. Upon these foothills in favored places are grown vines, rye, and potatoes—a small but superior variety. Ordinarily the lower slopes are steep and rocky, and hence the transition between field of the valley and waste land of the hills is abrupt. Elsewhere there are modifications of slope where better soils and ground water conditions exist. Though fields stretch up the slopes from the valleys, the foothill zone is marked definitely with a change in the character of the crop. A compound alluvial fan slope west of Fuilla is an exception. It is irrigated but not terraced and supports

grass. The isolated fields on the hills are so few that they have been mapped individually. They do not change greatly in crop from year to year. Mainly these fields are of vines and rye. Vines are grown on the foothills because they are a dry-land crop, can be grown on a steep slope, and profit by a high-degree angle exposure to the sun. But one small vineyard has a northern exposure. The vine terraces are not level; vines are not irrigated. Frequently a retaining wall a meter high marks the boundary of a vineyard which has a slope of 30 degrees. This wall serves to prevent soil from washing into a neighbor's field. The soil which is thus caught is carried at intervals by hand to the top of the field.

On the map (Fig. 2) are shown abandoned vine terraces cultivated in days of a more meager economy when there were a great number of people and less cash in the Conflent. Men could then be hired to work among the vines for a franc (pre-war) a day, women for seventy-five centimes, where now the laborer demands twenty-five francs if he can be hired at all. They carried the manure up the slopes in great baskets on the back, likewise carried the grapes down, and worked at cultivation with a back-breaking mattock. Lunch was a hunk of bread and an onion and perhaps a little wine. Today, with the increasing price of wine, the terraces are again beginning to be cultivated. The Catalan calls these hills *aspres* in distinction from the green irrigated bottoms known as *regatiu*.

Mountain Pastures, Forests, and Alpine Zone

The mountain pastures for goats and sheep are upon the fault face. For geologic reasons these have poor ground water, and it is a question whether they were ever forested. They do support, however, a forage suitable for goats and sheep, though the broom plant is an unfortunate element of the vegetal association. Goats are more numerous than sheep, because of the milk, each household owning one or more goats for this purpose. Ownership of land is communal, and the beasts are taken to pasture by a village herder.

The mountain forests in ascending order are successively oak, chestnut, beech, hemlock, and mountain pine. With better soil and ground water conditions on the less steep slopes above the fault face or canyon sides the forests are of excellent stand. The better ground water conditions are due to increased precipitation with altitude, snow (snow melting goes on through the first half of the summer), topographic relations, and summer mountain clouds. The clouds mean greater humidity and lessened evaporation. Not until the zone of the mountain pine is reached is the wind a large factor in evaporation; below that the slopes and valleys here mapped are protected from the prevailing southwest winds of summer. The forests furnish

fuel wood and lumber, though most of the fuel is gathered from pollard trees—chestnut, willow, and poplar—which line the valley roads, fields, and watercourses, rather than from the remote mountain forests. From the fields the laborer can carry home a load of fagots as he returns in the evening. The chief importance of the forests has long been recognized as that of regulator of water supply. Without irrigation water the valley economy would be miserable. The forests are largely owned by the communes, but some of the regulations governing them are national and date back to the time of Napoleon.

FIG. 11—It is not too great altitude, 1700 meters, but difficulty of access which caused this farm, Ferme de Randais, to be abandoned.

In the forest zone there are high-level cirque bottoms, flattish slopes, and tops of spurs where ground water seeps freely from the soil, today free from trees and covered with lush pasture. These *jasses*, as they are called, are the homes of the cattle in summer. The herd sleeps in the open about a shepherd's hut. Grazing extends into the forest, especially in the upper reaches where the scattered mountain pines permit a grass growth.

Above is a zone consisting of alpine herbage and rocks snow-covered for a large part of the year. Much of the terrain is uplifted, dissected peneplain spoken of locally as *pla*. These lands are pastures for sheep that remain aloft the whole of the summer. In some cases the sheep are transhumants from outside the Conflent. Originally

these areas were the home of the local wild mountain sheep, the *isard*. On one occasion I saw the unusual sight of eighteen of these shy animals in a single herd.

Height Limits of Fields

In the valley of the Cadi, on a northern exposure where the grade is at least a fifty per cent slope, is the abandoned Ferme de Randais (Fig. 11). The altitude of this ancient farm is 1700 meters. The best information is that vegetables and grains were successfully raised here. Because of steep slopes and the large amount of pasture land available, one suspects that the basis of the farm's economy was pastoral. The fact remains that at this altitude on a reverse, or northern, slope it was possible to raise crops successfully. The height limits of agriculture as represented by the highest fields in the valleys are then not a matter of decrease of temperature with altitude. Long before the climatic limits of tillages are attained topography, accessibility, and water for irrigation control the height limits of cultivation. The abandoning of the Ferme de Randais is a question of accessibility. Accessibility in this case is more a social matter than a physical one. In terms of the ease of life in France today the farm is too remote. But it is harder to understand the giving up of the village of St. Vincent, whose abandoned site is noted on the map. The village site is not two kilometers from Vernet-les-Bains and but slightly higher. Once again there is a question of accessibility and the attractiveness of life elsewhere. Also the decreasing population of the area in general has made the less desirable site of St. Vincent in less demand. Additional factors are the developing of mining and tourism in the lower valley as about Vernet.

The finer details of the limits of fields are usually topographic, topography influencing soil character, ground water, and the possibility of irrigation. The topography of the foothills that flank the lower valleys is such that gentler slopes (35 per cent) are not impossible of agriculture. In two ways per cent of slope influences tillage. Plow land is anything up to 40 per cent slope, and mattock-tilled fields are to be seen on much steeper slopes. The critical incline, as found upon the foothills, is that which is too steep for good ground water conditions. A slope of given incline will have a greater probability of verdure if it is situated upon the higher portions of the foothills near the rain-forming mountains.

Village Organization

The villages are clusters of squared-cobble houses about a fort-like chateau or church. The roofs are of tile, mellowed with years, and the walls of stone brown with iron. Few passageways between

the houses are wide enough for the oxcarts, and most of them are irregular stone-paved paths. Everywhere are fountains whose clear water, running free, keeps the gutters clean. Reminiscent of feudal days, but also representing the social nature of these mountaineers, the villages are huddled into a small space. The buildings outside the villages shown on the map are largely granges. In general the center of the village is no more than fifteen minutes' walk from the most distant field. Vernet, Sahorre, and Casteill are located near the upper edge of their valley basins so as to take advantage of both the valley and mountain economies. Corneilla and Vernet are situated where two valleys meet. Casteill is where the *Riu* Cadi first breaks from its gorge and makes irrigation practicable.

Résumé of the Economies

This region differs from most mountain regions in that within a short distance both foothill and mountain economies exist. The single farmer enjoys rights on terrain distinctly agricultural and on terrain that is forest and pastoral. The agricultural community situated in a broad extra-montane valley may thus directly control the forests and snow fields which regulate the irrigation water. The proximity of the two economies is due to the distinct fault face that exists there. The valleys are Mediterranean in aspect but have, thanks to their piedmont location, plentiful irrigation water. The pastoral life is not dominant as in most mountain districts, but it shares about equally with the agricultural interest. Agriculture is so important that there has been little depletion of forests in favor of pastures, for the importance of water conservation due to forests has been long recognized by these agriculturists. This is in distinction from many Mediterranean mountains. The lack of emphasis upon pastoral culture has failed to develop a seasonal migration of peoples to mountain pastures. Perhaps no more than two or three men to the village go aloft with the beasts in summer. There are no high-level summer villages. The towns have not suffered the population decrease common during the last ten years in Pyrenean regions. Two factors have militated to this end—the somewhat recent development of apple production and the interest given to iron mining since the war. Iron ores exist in both the mountain zone and the foothills, but in the region mapped the iron lies in the schistose rocks of the foothills. Though a number of the pits and tunnels ship by wagon to the railhead, there is one modern development with a railway and a roasting furnace for carbonate ores. There is at Vernet-les-Bains both a winter and a summer tourist season, for English and Spanish respectively. Tourism locally forms an important industry.

Thus the varying types of use of the land in the Conflent are complementary, each serving a purpose in the regional economy.

TOTEM POLES: A RECENT NATIVE ART OF THE NORTHWEST COAST OF AMERICA

Marius Barbeau
National Museum of Canada

FIG. 1—The Nass and Skeena River basins.

THE totem poles of British Columbia and Alaska on the northwest coast of North America have long since achieved world-wide repute. Their decorative style at its best is unique and so effective that it is nowhere surpassed in excellence among the other forms of aboriginal art at large. They express native personality and craftsmanship in terms impressive and intriguing. The museums of Europe and America treasure a number of them, principally from the Queen Charlotte Islands; some adorn the parks of our western cities. These picturesque creations, however, can be seen to full advantage only in their true home, at the edge of the ocean, amid tall cedars and hemlocks, and in the shadow of lofty mountains. With their bold profiles, reminiscent of Asiatic divinities and monsters, they conjure impressions strangely un-American in their surroundings of luxuriant dark-green vegetation under skies of bluish mist.

The art of carving poles belongs to the past. Racial customs and stamina are on the wane everywhere, even in their former strongholds. Totem poles are no longer made. Many of them have fallen from old age, decayed, and disappeared. Some were sold, others removed in maritime raids without the consent or knowledge of the owners. Quite a few were destroyed by the owners themselves during hysterical revivals under a spurious banner of Christianity; for instance the poles of two Tsimsyan tribes, in the winters of 1917 and 1918, at Gitlarhdamks and Port Simpson near the Alaskan frontier.

Not even a remnant of the famous clusters of former days remains among the Haidas of the Queen Charlotte Islands. Barely a few are still left among the Bellacoolas, the Kwakiutl, and the Nootkas

of the west coast of British Columbia; in a few years these will have totally disappeared.

The only collection of poles that still remains fairly complete is that of the upper Skeena, in British Columbia, a short distance southeast of the Alaskan border, from 150 to 250 miles inland, at the edge of the area where this art is practiced. Nowhere else but on the Nass, where a number of poles also survive, are they to be seen far inland. The Canadian Government and the Canadian National Railways a few years ago inaugurated the policy of preserving the Skeena River poles in their original location. And the Department of Education of the American Government is also restoring some of the Tlingit poles of the Alaskan coast.

Well known as is this striking form of native art, one is apt to suppose that our ethnographic literature is well supplied with data on their features and history. The supposition, however, is unjustified. Casual descriptions of poles or models of poles have been furnished by Dr. Swanton, Lieutenant Emmons, Dr. Boas, Dr. Newcombe, and others; but their notes usually appear without the necessary historical context. It is too late now to recover much of this knowledge. The present writer made a complete study of the poles of the three Tsimsyan nations, while engaged in several ethnographic explorations on the northwest coast for the National Museum of Canada from 1914 to 1927; and a summary of his conclusions is here presented.[1]

Significance of the Totem Pole

The characteristic figures on totem poles consist of symbols comparable to heraldic devices—not pagan gods or demons, as is often supposed. They usually illustrate myths or tribal traditions. They were never worshiped; and if they were held sacred, it was only because of their implications.

Those of the Tsimsyan and the Tlingit in particular—and the same thing is also largely true of the Haida poles—were monuments erected by the various families in the tribe to commemorate the dead. In intent they were the equivalent of our tombstones. Indeed, the natives now have some of their crests carved out of stone or marble at Port Simpson or Vancouver and place them as tombstones in their modern graveyards. The owners' object in thus showing their coat of arms was to publish at large their claims to vested rights and privileges. The emblems or totems varied with each family; they were their exclusive property and jealously guarded. They picturized legends, phenomena, and the animals of the country. The eagle, the raven, the frog, the finback whale, the grizzly bear, the wolf, the

[1] Published with the approval of the Director of the National Museum of Canada.

thunderbird, and many others are among the most familiar themes. Others less frequently seen appear to be more recent: for instance the owl, the salmon, the woodpecker, the beaver, the starfish, the shark, the halibut, the bullhead, the split person, the mountain goat,

FIG. 2—The mouth of the Nass River near Portland Canal.

the puma, the moon, the stars, and the rainbow. These symbols in the last resort were property marks.

The legendary origin of the emblems is explained in traditional narratives that used to be recited in the winter festivals or potlatch. They are still remembered by the members of the older generation, in spite of the decay of tribal customs. They recount how the ancestors long ago met with tribulations and adventures; how they were harassed or rescued by spirits and monsters of the unseen regions; how benevolent spirits appeared in visions and invested their protégés with charms; and how ancient warriors conquered their enemies. The carved illustrations of the stories served a definite purpose, besides those of commemoration and ownership; they made familiar the legends and recollections of the past to all in tribal life.

Soon after the death of a chief his prospective heirs appointed his leading nephew to his post. His induction took place in the midst of a large number of invited guests during elaborate festivals, where liberality was an outstanding feature. The name of the uncle passed on to his nephew, and the erection of a totem pole crowned the event. Groups of related families mustered all available resources to make the feast memorable, as their standing and influence depended exactly on their resources thus advantageously displayed.

MAKING AND ERECTING A POLE

The labor of cutting a large red cedar tree, hauling it overland or on the sea for a considerable distance, carving it, and erecting it often required years. The owners required sufficient time to gather their resources and proceeded with expenditures in instalments, as it

were. A tree was first selected and felled. The allies of the family interested took charge of the work—no relative could accept the stipend. They were fed and paid publicly at the conclusion. A carver was then hired also from among the allies. Should he lack the required

FIG. 3—Gitwinlkul, a Gitksan village on the Grease Trail between the Nass and the Skeena, summer of 1924. Writer's camp in the foreground.

skill, it was his privilege to appoint a substitute, over whom he stood ceremonially, assuming the credit of the work for himself. The carving was accomplished as secretly as possible, the figures being selected by the owners from their list of available crests, which often exceeded the fingers of one hand in number. Far more costly was the actual planting of the pole in the ground. When enough food and wealth were amassed, invitations were sent forth to all the leading families of the neighboring tribes; and the pole was erected in the presence or with the help of the hundreds of people gathered in festivities that were the corner stone of social life until about forty years ago.

These carved memorials as a rule face the water front, and the rivers or the ocean were the main highways. They stand apart from one another, in front of the owners' houses, and dot the whole length of the village in an irregular line. In recent years the villages have been moved to new sites, and the poles seem forsaken in the deserted abodes of the past. Trees have grown up around them in several places, and it is difficult to find them—particularly along the Nass.

DEVELOPMENT OF THE ART OF THE TOTEM POLE

Enough material has been retrieved from oblivion for a detailed history of Tsimsyan plastic art and the making of totem poles. Our study covers over 150 such memorials. The villages of the upper Skeena are the only ones that still retain some of their earlier barbaric features. Kispayaks, Gitsegyukla, and Kitwanga each claim about twenty poles. Gitwinlkul now is the most remarkable of all the tribal villages. It stands on the Grease Trail from the Skeena to the

Nass, claiming the largest number of poles now standing anywhere in a single cluster—about thirty in all. It is impressive. Its poles are among the tallest and best; they are also the oldest.

It is evident that the carving of the poles was a truly popular art. If some artists were at times preferred to others for their skill, their choice for specific tasks was governed by customs largely unconcerned with craftsmanship. Each family of standing had every inducement to resort to its own carvers for important functions in ceremonial life. We have statistical evidence of this. The hundred totem poles of the upper Skeena were produced by more than thirty local carvers and thirteen foreigners. Six of the foreigners were from the Nass, and they had been engaged in the earliest period when the Skeena artists were not yet proficient in the new calling; three others were from the lower Skeena, and four from the Bulkley River, a tributary of the Skeena. The Skeena carvers belonged to independent and widely scattered social groups or families; that is twenty-three of them were of the Raven-Frog phratry; nine of the Wolf, five of the Eagle, and three of the Fireweed. Seventy-eight out of the hundred poles are ascribed to Gitksan artists, while the rest are credited to foreigners.

The art of carving and erecting memorial columns is not really as ancient on the northwest coast as is generally believed. Popular misconceptions that totem poles are hundreds of years old are fantastic. They could not be, from the nature of the materials and the climatic conditions. A green cedar cannot stand upright much longer than fifty or sixty years on the upper Skeena, where precipitation is moderate and the soil usually consists of gravel and sand. Along the coast it cannot endure the intense moisture that prevails most of the year and the muskeg foundation much more than forty years. The totem poles of Port Simpson, for instance, all decayed on the south side first, which is exposed to warm rainy winds. Most of the well known poles now in our parks and museums were carved after 1860; while not a few of those seen in Indian villages, such as Alert Bay, were erected after 1890.

The growth of native technique to its present state is largely confined to the past century. It hinged upon European tools—the steel ax, the adze, and the curved knife—which were traded off in large numbers to the natives from the days of the early circumnavigators—that is after 1778. The lack of suitable tools, of wealth, and of leisure in the prehistoric period precluded the elaboration of ambitious structures and displays. The benefits accruing from the fur trade at once stimulated local ambitions; they stirred up jealousies and rivalries and incited incredible efforts for higher prestige and leadership. The totem pole came into fashion after 1830 through the rise of these ambitions. The size of the pole and the beauty of its figures published abroad the fame of those it represented.

Feuds over the size of poles at times broke out between semi-independent leaders within a village. The bitter quarrel between Hladerh and Sispegoot, on the Nass, will not soon be forgotten. Hladerh, head chief of the Wolves, would not allow the erection of any

FIG. 4

FIG. 5

FIG. 4—Two poles at Kispayaks, erected at twenty years' internal in the memory of two successive chiefs.

FIG. 5—The pole of Tralarhaet, a Beaver-Halibut clan of the Eagle phratry, at Gitiks. The crests illustrate the myth of a migration southwards of the owners.

pole that exceeded his own in height. Sispegoot, head chief of the Finback Whales, could afford to disregard his rival's jealousy. When his new pole was carved, more than sixty years ago, the news went out that it would be the tallest in the village. In spite of Hladerh's repeated warnings, Sispegoot issued invitations for its erection. But he was shot and wounded by Hladerh as he passed in front of his house in a canoe. The festival was perforce postponed for a year. Meanwhile Hladerh managed, through a clever plot, to have Sispegoot

murdered by one of his own subordinates. He later compelled another chief of his own phratry, much to his humiliation, to shorten his pole twice after it was erected; and he was effectively checked only when he tried to spread his rule abroad to an upper Nass village.

The present crop of poles is the first of its kind to stand on the Skeena, with the exception of a few of the oldest that have already fallen and decayed. The oldest poles of Gitsegyukla (at Skeena Crossing) have stood only since the fire destroyed the earlier village in 1872; those of Hazelton were carved after the establishment of the Indian reserve about 1892. But several of the poles in the other villages—including Kitwanga—are many years older; they are particularly interesting, as they illustrate the growth of totem pole carving within two or three generations in the nineteenth century.

Most of the poles of the upper Skeena were erected in the past forty or fifty years. The oldest five or six may slightly exceed seventy years of age. Not a few are less than thirty years old. It is safe to say that this feature of native life among the Gitksan became fashionable only after 1870 and 1880. Only six out of nearly thirty poles at Gitwinlkul—the earliest of these villages to adopt the art—exceed fifty years of age; and only a few poles at that time stood in the neighboring villages.

Technique and Its Evolution

Native accounts and the evidence of the carved memorials lead to the conclusion that, among the Tsimsyan, carved house-front poles and house-corner posts were introduced first, many years before the first detached columns appeared. Several houses and posts of this kind are still remembered by the elders and have been described; a few are still to be observed, particularly at the lower canyon of the Skeena, though most of them are in an advanced state of decay. The archaic style of house decoration was abandoned as soon as the natives gave up building large communal lodges in the purely native manner, and memorial columns that could no longer serve as ceremonial doorways, or traps, became the new fashion. Some of the upper Skeena villages, indeed, never adopted the fashion wholesale; at least four of them boasted of no more than a few poles, and part of these were put up only after 1890.

Internal evidence tells the same tale. The technique of carving on several of the oldest poles on the upper Skeena discloses anterior stages in the art. It is essentially the technique of making masks or of carving small detached objects; or, again, of representing masked and costumed performers as they appeared in festivals rather than the real animals or objects as they exist in nature. These early Skeena River carvers had not yet acquired the skill of their Nass River masters, who had advanced to the point of thinking of a large

pole as an architectural unit that called for harmony of decorative treatment.

Haesem-hliyawn and Hlamee, of Gitwinlkul, represent distinctive periods of the craft among the Gitksan. To Haesem-hliyawn goes

FIG. 6

FIG. 7

FIG. 6—Totem poles at Gitwinlkul, carved by Haesem-hliyawn, a leading carver about 50 years ago.
FIG. 7—Totem poles at Gitwinlkul, carved by Hlamee, a later-day follower of Haesem-hliyawn.

the credit of carving some of the best poles in existence. He lived as late as 1868, while Hlamee, his junior and follower, died after 1900.

The style of Haesem-hliyawn was of the finest, in the purely native vein. He combined a keen sense of realism with a fondness for decorative treatment. His art sought inspiration in nature, while maintaining itself within the frontiers of ancient stylistic technique.

Haesem-hliyawn belonged to the generation wherein the totem pole art was still in its growth (1840–1880) and all at once reached its apogee. His handling of human figures counts among the outstanding achievements of west coast art—indeed, of aboriginal art in any part

FIG. 8

FIG. 9

FIG. 8—One of the oldest and finest poles in existence, at Gitwinlkul; formerly a house-front portal, the ceremonial entrance being through the opening at the bottom.
FIG. 9—One of the finest old poles at Angyederh on the lower Nass.

of the world. The faces he carved, with their pronounced expression and amusing contortions, are characteristic of the race.

Hlamee, a prolific worker, introduced the white man's paint to enhance the features of his carvings. While he used paint with discretion and to good effect, it immediately lessened the sculptural

quality of the work. The new fashion did not compensate for the evident loss of native inspiration and artistry.

The carved poles of the Nass maintain a much higher average standard of art than those of the Skeena; but they are less numerous,

FIG. 10

FIG. 11

FIG. 10—An Eagle pole at Gitiks, the former Nass River village nearest to the Alaskan border. This is one of the finest and tallest poles in existence.

FIG. 11—Totem poles at Kitwanga (the Rabbit-tribe), on the upper Skeena. The nearest pole—that of the ensnared-grizzly—counts among the finest. It was carved by Haesem-hliyawn about 60 years ago.

for the reason that the Nass people gave up their ancient customs much earlier than the Gitksan—that is forty or fifty years ago. The technique of pole carving in both areas represents well the passage from the earlier and better art of the Haesem-hliyawn type to that of Hlamee.

The Tsimsyan of the lower Skeena, on the other hand, never were devoted to the art of carving totem poles. When they were moved long ago to commemorate a historical event of first magnitude, they erected a tall slab of stone. If the Tsimsyan proper as a body were not swayed by the modern fashion of erecting carved memorials to their dead, they retained until fairly late the older custom of painting in native pigments their heraldic symbols on the front of their houses. While not a single totem pole seems ever to have stood in the village of Gitsees, near the mouth of the Skeena, five house-front paintings were still clearly remembered and described a few years ago. And it was related that many houses in the neighboring tribes were decorated in this style, which at one time may have been fairly general along the coast.

FIG. 12—Menesk, the Eagle head chief of Gitlarhdamks, on the upper Nass. His carved headdress and old Chilkat robe are among the finest and most valuable of the kind.

The remarkable west coast custom of carving and erecting house poles and tall mortuary columns or of painting coats of arms on house fronts is sufficiently uniform in type to suggest that it originated in a single center and thence spread outward in various directions. The limits of its distribution coincide with those of the west coast art proper which embrace the carving or painting of wood, leather, stone, bone, and ivory.

This art itself seems much more ancient in some of its smaller forms than in its larger ones. Its origin on the northwest coast is remote. It goes back to prehistoric times. It was already in existence and fully mature and quite as conventionalized as it is today at the time of the early Spanish, English, and French explorers (1775–1800). Most of the early circumnavigators—Cook, Dixon, Meares, Vancouver, Marchand, and La Pérouse—give ample evidence that masks, chests, ceremonial objects were at the end of the last century decorated in the style now familiar to us. They also mention that house fronts were decorated with painted designs. There is, however, a striking lack of evidence everywhere as to the existence of totem poles proper or detached memorial columns, either south or north. For instance,

Dixon examined several of the Haida villages on the Queen Charlotte Islands; but he fails to mention totem or even house poles, even though he minutely described small carved trays and spoons.

But there were already, from 1780 to 1800, some carved house posts in existence. Captain Cook[2] observed a few carved posts inside the house of some chiefs at Nootka Sound, where he wintered in 1780; and Webster, his artist, reproduced the features of two of them in his sketches. Meares, in 1788 and 1789, observed like Nootka carvings in the same neighborhood, which he describes thus: "Three enormous trees, rudely carved and painted, formed the rafters, which were supported at the ends and in the middle by gigantic images, carved out of huge blocks of timber."[3] And he calls them elsewhere "mishapen figures." The earliest drawing of a carved pole is that of a house frontal or entrance pole (not a real totem pole) of the Haidas; and it is found in Bartlett's Journal, 1790.[4]

FIG. 13—Semedeek, an old Eagle chief of Kitwanga, on the upper Skeena. His headdress shows his Eagle crest. His robe is a Chilkat.

ORIGIN OF THE TOTEM POLE ART

The custom of carving and erecting mortuary columns to honor the dead is therefore modern, that is post-Columbian; it may exceed slightly the span of the last century. In spite of this, it is not easy to trace back its origin to its very birthplace. Even the simple poles of the Nootkas as described by Cook are not likely in themselves to represent a form of native art of the stone age in its purely aboriginal state, undisturbed by foreign influences. Iron and copper tools at that date were already in the possession of the natives; and they were used everywhere as only they could be by expert craftsmen through lifelong habit. The west coast at that date was no longer unchanged. The Russians had discovered it many decades before,

[2] James Cook: A Voyage to the Pacific Ocean (3 vols., London, 1784), Vol. 2, p. 317.

[3] John Meares: Voyages Made in the Years 1788 and 1789, from China to the North West Coast of America, London, 1790, p. 138.

[4] Cf. "The Sea, the Ship and the Sailor: Tales of Adventure," etc., with an introduction by Captain Elliot Snow, Salem, Mass., 1925.

and the Spanish had left more recent traces of their passage. Moreover, the influence of the French and the English had crossed the continent through contacts between intermediate tribes and the arrival of halfbreeds and *coureurs de bois* west of the mountain passes. From our records of exploration and adventure it appears certain that the northwest coast people were accessible to foreign influence for more than two hundred years, to say the least. The natives themselves were highly amenable to foreign influence. Nowhere in America did they show more avidity or greater skill to acquire and utilize from the sundry goods and crafts of the white man whatever suited their needs.

Precisely where the totem poles, or mortuary columns, first appeared and at exactly what moment is an interesting, though elusive, point. Our evidence eliminates the Gitksan, or the Tsimsyan proper, from among the possibilities. Evidence abundantly shows that the Nass River tribes made totem poles at an earlier period than the upper Skeena people. Many families on both sides were mutually related. Several of the Gitwinlkul villagers have their hunting grounds on the upper Nass; and the Gitksan used to travel every spring to the lower Nass for eulachan fishing or to trade pelts or dried fruit cakes with the coast tribes. In the course of time a strong cultural influence from the more progressive tribes of the coast thus resulted.

Likewise the tribes farther south cannot be considered. The Bellabellas were painters rather than carvers. The Kwakiutl and the Nootka plastic art always remained very crude compared with that of the northern nations; and, besides, it reveled in grotesque forms by preference. It seldom was at the service of heraldry as in the north, heraldry being of minor import on the coast south of the Skeena. Totem poles among the Kwakiutl and the Nootka are all very recent; not many of them, as they are currently known, may antedate 1880. The most familiar of the Kwakiutl poles, those of Alert Bay, were all carved and erected since 1890. None of them stood at the time when the late C. F. Newcombe visited the village at that date.

At first sight it seems more likely that the Tlingit, of the southern Alaskan frontier, might have initiated the custom of erecting memorials to the dead. They were closer to the Russian headquarters and must have been among the first to obtain iron tools. There is no doubt, besides, that they were most skillful carvers and weavers, through the whole local evolution of these crafts. Yet there are good reasons why the credit for originating totem poles should not fall to their lot. The early circumnavigators that called at some of their villages made no mention of large carvings that we know, not even of such house or grave posts as they observed among the Haidas farther south. From a keen and experienced observer of these people, Lieutenant G. T. Emmons, who was stationed on the Alaskan coast

for many years in an official capacity, we learn that the northern half of the Tlingit nation never had totem poles until very recently; and the few of those that have sprung up in that district within the scope of his observation are the property of a family or families that originally belonged to the southern tribes and have retained their southern affiliations.

The Haidas must next be dismissed from consideration as likely originators of the art. The Haida poles, as we know them, are partly house poles and partly totem poles proper; the former far more numerous proportionally than among the Tsimsyan. Indeed, almost none of the present Nass River carvings were house poles. The two large posts observed among the Haidas by Bartlett and Marchand in 1788–1792 were house portals. Though the Haida villages were often visited at the end of the eighteenth century and in the first part of the nineteenth, we find no other reference to large poles, still less to the famous rows of poles at Massett and Skidegate as they were photographed about 1880. The Haida poles as we know them in our museums are all of the same advanced type of conventionalism, all of the same period, that is 1830–1880, and presumably all from the hands of carvers that were contemporaries. They were from ten to thirty years old when the Haidas became converts to Christianity and in consequence gave up their customs, cut down their poles, and sold them to white people about the year 1890 or afterwards. It is a common saying, however inaccurate it may be, that the fine row of poles in one of their best known towns had risen from the proceeds of an inglorious type of barter in Victoria. There is no evidence of mortuary poles among the Haidas antedating 1840 or 1850, though a few earlier and transitional ones may have served to introduce the fashion.

The probabilities are that totem poles proper originated among the Nisrae or northern Tsimsyan of the Nass River. It is evident, from traditional recollections, that the custom of thus commemorating the dead is not very ancient among them; yet it certainly antedated that of the Gitksan or the Tsimsyan. It is far more likely that the Haidas and the Tlingit imitated them than the reverse. The estuary of the Nass was the most important thoroughfare of Indian life in all the northern parts. Eulachan fishing in the neighborhood of what is now called Fishery Bay near Gitrhateen, the largest Nisrae center, was a dominant feature in native life. The grease from the eulachan, or candlefish, was a fairly universal and indispensable staple along the coast. For the purpose of securing their supply of it the Haidas, the Tlingit, the Tsimsyan, and the Gitksan traveled over the sea or the inland trails every spring and camped in several temporary villages of their own from Red Bluffs eastwards on the lower Nass, side by side, for weeks at a time. During these yearly seasons exchanges

of all kinds—barter, social amenities, or feuds—were quite normal. As a result, cultural features of the local hosts—whether they were willing hosts or not is an open question—were constantly under the observation of the strangers and were often a cause for envy or aggression. It is doubtful, on the other hand, whether the Tsimsyan ever traveled to the Queen Charlotte Islands or the Tlingit country unless to make a raid or an occasional visit to relatives.

It is agreed among specialists that the Nass River carvers were on the whole the best in the country. Their art reached the highest point of development ever attained on the northwest coast. And their totem poles—more than twenty of which can still be observed in their original location—are the best and among the tallest seen anywhere. The Haida poles are stilted, conventional, and offer little variety in comparison. It is noteworthy, besides, that the Tlingit poles resemble in character those of the Nass River. And the Nisrae assert that a number of totem poles at Tongas (Cape Fox), the southernmost of the Tlingit villages, were the work of their carvers within the memory of the passing generation.

The close similarities between the plastic arts of the northwest coast and those of the various people around the edges of the Pacific Ocean should not be overlooked. Common features in the art and technology of our coast natives and the Polynesians, for instance, are too persistently alike in some aspects to be unrelated, at least in some remote way. The early navigators noticed, about 1780–1790, the striking resemblance between the fortresses of the Haidas and other coast tribes and the *hippah* of the New Zealand natives. Totem poles, as fairly recently carved and erected on both sides of the Pacific, offer the same compelling resemblance. Their technique of erection, besides, was identical. It will gradually become an established conclusion, we believe, that much of the growth of native crafts in wood carving and decoration *as now exemplified in the museums* of the world is far more recent than is generally believed.

THIRTY THOUSAND MILES OF BAROGRAPH CURVES

Robert DeC. Ward

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A CONTINUOUS round-the-world voyage, westward from New York to New York, has recently been made by the writer. The trip was planned primarily in order that first-hand knowledge might be gained of the great wind belts over the oceans and of the weather types associated with them. It was essentially what the late Ralph Abercromby so happily termed "a wandering in search of weather." The steamer, the *President Monroe*, sailed from New York on February 14 and returned on May 28, 1929. Short stops were made at nineteen ports: Havana, Cristobal, Balboa, San Pedro, San Francisco, Honolulu, Kobe, Shanghai, Hongkong, Manila, Singapore, Penang, Colombo, Suez, Port Said, Alexandria, Naples, Genoa, and Marseilles. The total distance traveled was, in round numbers, 30,000 miles. The instrumental equipment taken was intentionally simple, consisting only of a sling psychrometer and a small-sized Richard barograph. The barograph had been taken on previous voyages, including one in 1897–1898 from New York down the east coast of South America, through the Strait of Magellan, and back up the west coast. It also accompanied the writer on the International Ice Patrol in the summer of 1923. During the round-the-world voyage this same faithful instrument functioned perfectly. For one hundred and three days it kept its record without a break and thus completed nearly forty years of service.

The barograph sheets for fourteen full weeks and for portions of two additional weeks are before the writer as he recalls the weather conditions that were experienced while the pressure record was being made. It seems probable that this series of complete barograph curves from one continuous voyage around the world is unique. At any rate, no account of any similar series appears to have found its way into meteorological literature. While nothing essentially new or surprising as to pressure variations was discovered on the voyage, the curves are so instructive from the point of view of a teacher of meteorology and are so interesting to the writer that he believes a brief summary of the essential facts illustrated by them may be interesting and useful to others.[1] The barograph curve was always

[1] See also Robert DeC. Ward: A Climatologist's Round-the-World Voyage, *Monthly Weather Rev.*, Vol. 57, 1929, pp. 277–291.

started at the beginning of each week's sheet on local time. When the ship was steaming westward, there was, of course, a considerable time error by the end of the week. This error was greater or smaller as the ship's progress was more or less rapid and as her course was more or less directly west.

As was to be expected in mid-February, a well developed cyclonic depression with gales and heavy seas was encountered soon after the ship left New York on the voyage to Havana. The barograph curve showed the passage of a primary and of a secondary low pressure center (29.68 in. and 29.76 in.). As reported by radio, this storm forced Colonel Charles A. Lindbergh to land at Cape Hatteras Inlet on a return flight from Central America. Three days out from New York (in about latitude 27° N.) the diurnal variation of the barometer first appeared. Although the barograph curve in the tropics is characteristically and monotonously regular, and although the writer has seen it repeated week after week on this voyage as well as in previous years, there is something of compelling interest in the regular recurrence of the same double daily maximum and minimum. Alexander von Humboldt made the statement that in the tropics the time of day can be told within less than 20 minutes if the pressure reading is known.

One of the most interesting records secured was that during the passage through the Panama Canal. The changes in pressure as the steamer was raised and lowered through the locks were clearly indicated in the irregularity of the curve. While this condition must surely have been noticed by many other observers, no mention seems to have been made of it, in terms of the barograph curve, by any previous writer. Because of its interest in connection with this fact, the curve for the week February 18–25 is here reproduced. The *President Monroe* reached Havana on the afternoon of February 18 and made the passage through the Panama Canal on February 22, continuing her voyage up the coast to San Pedro. The curve also shows the beginning of the diurnal variation on February 18 and the gradual lowering of the pressure with the decreasing latitude towards the Isthmus of Panama (I).

The first part of the voyage up the west coast of Central America and Mexico showed a continuation of the diurnal variation combined with a general rise in pressure as higher latitudes were entered (II). The former type disappeared on March 1 (noon latitude 24° N.)

On the voyage from San Francisco to Honolulu, a day out of San Francisco, the prevailing westerlies provided a beautiful example of a "temperate zone" cyclone, with gales and rain and snow squalls along the wind-shift line. The rapid fluctuations in pressure as the barometer rose are clearly seen on the barograph curve (III).

After the axis of the North Pacific anticyclone was passed, the

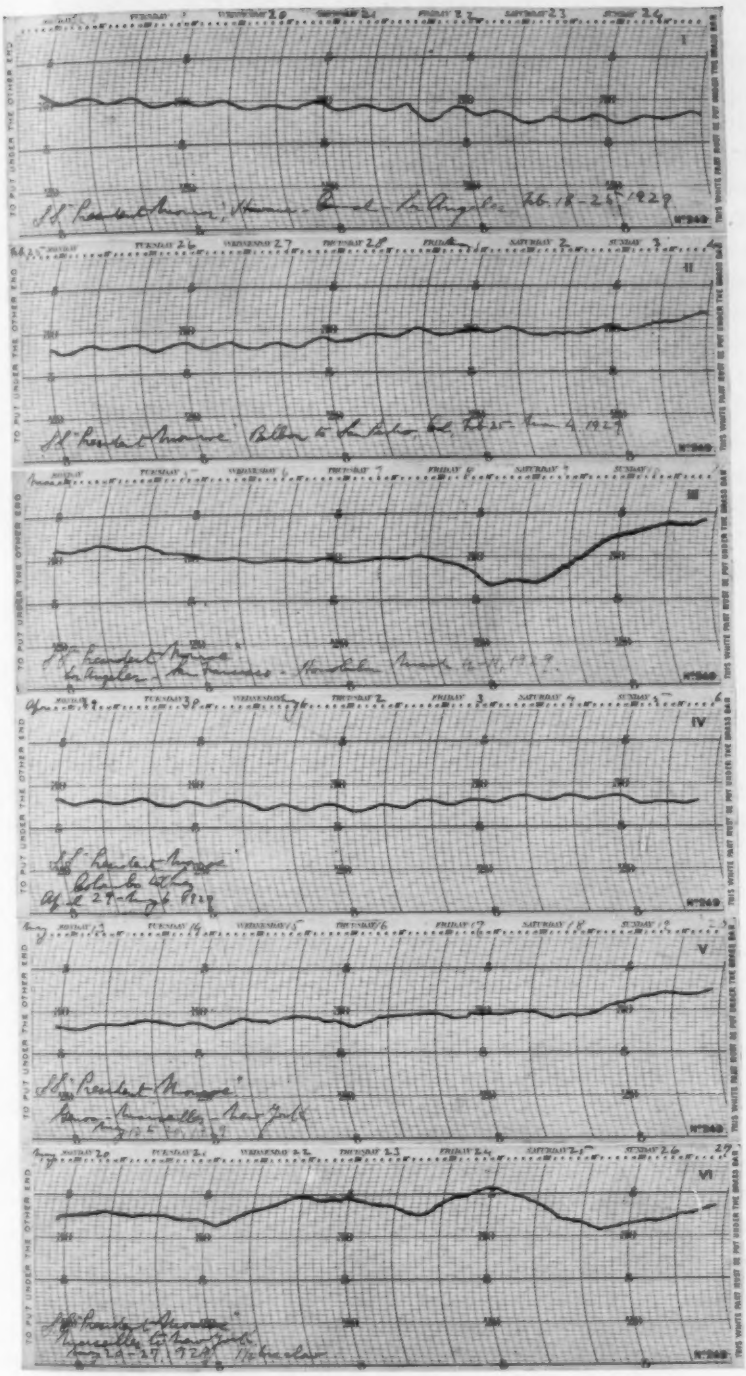


FIG. 1—Selected barograph curves. Note in I effect of passage through Panama Canal (Feb. 22); II, disappearance of diurnal variation with increasing latitude; III, passage of cyclonic storm; IV, diurnal variation; V, occurrence of mistral May 15–16; VI, characteristic pressure curve on southern route of transatlantic liners (spring).

barometer began to fall again slowly, and the diurnal variation again appeared, faintly at first (March 12; noon latitude 29° N.) and then clearly, and continued to Honolulu and after departure from Honolulu for Kobe until March 18 and 19 (noon latitudes 24°–26° N.), when, in a rather surprisingly low latitude, violent southwest followed by northwest squalls occurred. These were not accompanied by any noteworthy fluctuations of pressure but only by slight and rapid oscillations. The curve continued with minor irregular fluctuations until a maximum pressure (30.39 in.) was reached in latitude 26° N. Showers on March 23 (noon latitude 28° 30′ N.) were unaccompanied by a fall in pressure, which was over 30 inches, although minor fluctuations of short duration were clearly indicated; but a general cyclonic rain on March 27 (noon latitude 33° N.), without strong winds, was associated with a slow and moderate fall and rise of the curve. The ship was clearly well south of the center. An overcast, chilly day at Kobe, followed by showers, came on the rise of the barometer (maximum 30.25 in.).

Between Kobe and Shanghai the pressure was steady, over 30.00 in., with a northeast wind blowing out of an anticyclone to the north. This wind, which was distinctly chilly, continued at Shanghai with overcast skies. The conditions were essentially similar to a northeast spell of weather on the northern Atlantic coast of the United States in spring. The diurnal variation showed faintly and with some irregularities at Shanghai (latitude 31° N.) and during the voyage southward to Hongkong (latitude 22° N.). From Hongkong to Manila and from Manila to Singapore, Penang, Colombo, and Suez there was a beautiful repetition, day after day for a month, of that wonderfully regular daily oscillation. As an illustration of this series of curves, the record for part of the voyage from Colombo to Suez is herewith reproduced (IV).

It will be observed that the diurnal variation faded out on May 5, the day before Suez was reached (noon latitude 20° N.).

From Suez through the Canal and across the Mediterranean, as subtropical latitudes were again reached, the pressures were steady, with slight traces of the diurnal variation on the first two or three days and after that only slight and irregular fluctuations.

The occurrence of a well defined mistral, marked by a northwesterly gale accompanied by sharp squalls of brief duration, before and after we reached Marseilles and while we lay at dock in the harbor, gives a special interest to the barograph curve during that period (V). The first heavy gusts of the mistral began about 4 a. m., May 15, and the gale died out as the area under its control was left behind on the morning of May 16. The pressure, it will be observed, was somewhat below 30 inches, there being no marked depression. It is therefore obvious that the steep gradient that caused the violent

wind velocities was due in large measure to high pressures to the northward over central Europe.

The last lap of the long voyage was that from the Strait of Gibraltar to New York. When we were back in the prevailing westerly winds, the barograph curve once more resumed the irregular fluctuations associated with the passage of temperate zone cyclones and anticyclones (VI). A westward voyage in the stormy westerlies is obviously more interesting, from the point of view of the changes in pressure and in weather, than is an eastward voyage, because the former, taking the ship towards the eastward-moving lows and highs, gives her more frequent changes and more variety. The *President Monroe* was on the southern route, following lower latitudes than those covered on the northern route from the north of Europe to New York. Therefore the pressures averaged high. Two well marked anticyclones and three weak cyclonic depressions were encountered. The centers of the latter were well to the north—as was clearly indicated by the type of curve, the pressure readings, the weather conditions themselves, and the broadcasts from the Arlington radio station.

RECENT PROGRESS IN GRAVITY DETERMINATIONS AT SEA

C. H. Swick

U. S. Coast and Geodetic Survey

THE Meinesz method for making accurate determinations of gravity at sea has opened up a large field of investigation. Geodesists and geophysicists in all parts of the world have become greatly interested, and already several countries are taking steps to coöperate in making a gravimetric survey of the oceans. The thanks of the scientific world are due to the Navy of Holland, to the Netherlands Geodetic Commission, and to Dr. F. A. Vening Meinesz, an officer of that Commission, for their pioneering labors in this field.

Gravity observations on land have proved that isostasy exists under the continents, that is that there is approximately the same amount of material in each unit prism of the earth's crust above a level surface about 60 miles below sea level.[1] Along the coastal plain, for example, the unit prism has a length of 60 miles and under the Himalayan Mountains a length of about 63 miles; and since the masses are equal the densitites must be different. The gravity work at sea enables us to make similar studies for the ocean areas in order to learn whether isostasy exists there too and, if so, what are the variations from the ideal condition.

A brief account of the first gravity-at-sea expedition of Dr. Meinesz is contained in a previous number of this journal.[2] On that expedition Dr. Meinesz was able to measure the intensity of gravity at thirty-two stations between Holland and Java with much greater accuracy than had ever before been obtained at sea. His instrument consisted of a modified form of the von Sterneck pendulum apparatus, equipped with a photographic recording device. This he had mounted in a submarine which, during the observations, submerged deep enough to be only slightly affected by wave motion.

That first expedition took place in 1923. Since then Dr. Meinesz has completed two other important gravity-at-sea expeditions and at the present time is making an intensive gravimetric study of the waters near the Dutch East Indies. At the beginning of 1929 he had determined gravity at about two hundred and fifty sea stations, and

[1] See William Bowie: Isostasy, New York, 1927.

[2] C. H. Swick: Gravity Determinations at Sea, *Geogr. Rev.*, Vol. 15, 1925, pp. 466–469.

he expects nearly to double this number by the time his present project is completed.

Improvements in Apparatus

The apparatus in present use is quite different from that employed on the first expedition. It was designed by Dr. Meinesz in the light of the experience gained at those first thirty-two stations.

Before this apparatus can be described certain fundamental points about the Meinesz method must be briefly explained. If two pendulums of about the same virtual length rest on the same support, have their centers of suspension at the same height, and swing in the same plane but out of phase, it is possible by the use of vector analysis to combine their oscillations and obtain a hypothetical pendulum whose oscillations are not affected by small horizontal accelerations of the support in the direction of oscillation of the pendulums. In the modified von Sterneck apparatus, previously mentioned, there were two pairs of pendulums, and the recording device was so arranged that the oscillations of each pendulum were recorded separately. An analytical method, tedious and time-consuming, was necessary to combine the oscillations and derive the corresponding hypothetical pendulum.

The new apparatus was designed to overcome this difficulty. It is so arranged that the combined or relative oscillations of the two pendulums of a pair are traced directly on the record instead of the oscillations of each pendulum separately as in the original apparatus. This results in an enormous saving of time in making the computations. It also tends to increase the accuracy of the derived quantities and gives less opportunity for the making of errors in the computations.

Recent Sea Determinations

When his new apparatus was completed Dr. Meinesz gave it a thorough test at about a dozen stations between Holland and Port Said. This test was entirely successful. The next year, 1926, he started on his ambitious program of determining gravity at a string of points from Holland to Java by way of the Panama Canal and thus completing, when taken with his 1923 stations, a circuit of the globe with gravity-at-sea stations.

In a submarine, sailing without a mother ship, he left Holland in May, 1926, and, after crossing the Atlantic by way of the Azores, Canary Islands, and West Indies, passed through the Panama Canal, followed up the North American coast to San Francisco, and then crossed the Pacific by way of Hawaii, Guam, and the Philippines, reaching Java in December, 1926. More than one hundred and twenty-five gravity determinations were made on this trip.[3]

[3] F. A. Vening Meinesz: Provisional Results of Determinations of Gravity, made during the Voyage of Her Majesty's Submarine K XIII from Holland via Panama to Java, *Proc. K. Akad. van Wet., Amsterdam*, Vol. 30, 1927, pp. 743–755.

Before returning to Holland Meinesz observed about twenty-five stations south of Java in an effort to determine the gravimetric conditions near the edge of the continental shelf.

In September, 1928, at the invitation of the Carnegie Institution of Washington, Dr. Meinesz brought his apparatus to America and, in coöperation with that organization and the United States Navy, made about fifty determinations in the Gulf of Mexico, the Atlantic Ocean, and the Caribbean Sea.[4] On this trip he was accompanied by two American observers, one from each of the institutions mentioned above. These observers made a careful study of the instrument and its manipulation and became expert in the use of the apparatus and in the theory of the computations. Recently the Carnegie Institution purchased a Meinesz gravity apparatus, which was installed on the Institution's magnetic ship, the *Carnegie*, when the ill-fated vessel[5] reached San Francisco in the summer of 1929. Results of much value were anticipated, for, although this was the first thorough test of the apparatus on a surface vessel, Dr. Meinesz was confident that satisfactory results could be obtained on the days when the water was smooth and the rolling and pitching of the ship were moderate.

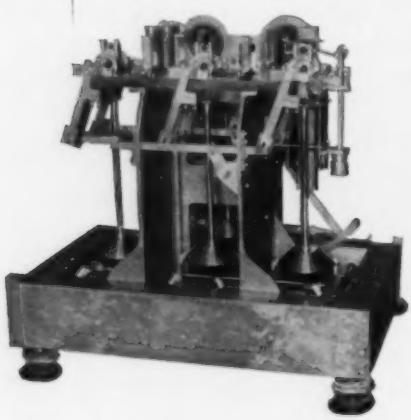


FIG. 1—Meinesz pendulum apparatus with cover removed. The three principal pendulums are plainly visible in front.

PRESENT APPARATUS AND METHODS

A recent publication of the Netherlands Geodetic Commission,[6] printed in English, contains a detailed description of the Meinesz apparatus with full instructions for its use and a clear exposition of the theory of the method.

The instrument consists of two principal parts, the pendulum apparatus itself and the recording device. The latter is mounted directly above the former and is attached rigidly to it. Two accurate chronometers form an auxiliary part of the apparatus. With the exception of the chronometers the whole apparatus is supported in

[4] F. A. Vening Meinesz: A Gravity Expedition of the U. S. Navy, *ibid.*, Vol. 32, 1929, pp. 94–99. See also *Nature*, No. 3099, Vol. 123, 1929, March 23, pp. 473–475.

[5] The *Carnegie* was destroyed by an explosion on November 29, 1929, in the harbor of Apia, Western Samoa, and her commander, Captain J. P. Ault, was killed. At the time the *Carnegie* had completed about 45,000 nautical miles of her seventh cruise which had been planned to cover the period May, 1928–September, 1931.

[6] F. A. Vening Meinesz: Theory and Practice of Pendulum Observations at Sea, Delft, 1929.

a gimbal framework in order to maintain it as nearly as possible in a level position during the observations, even when the ship is somewhat affected by wave motion. The vital part of the apparatus consists of the three principal pendulums (see Fig. 1). These are all of the same virtual length, are supported at the same height on three carefully ground agate planes, and swing in the same vertical plane with very nearly equal periods of oscillation. During the observations all three swing at the same time. The two outside pendulums are started in such a way that they will oscillate out of phase with each other. The middle one is not started by hand but is released when the others are started and is soon put in oscillation by the motion of the ship. The oscillations of the middle pendulum relative to a vertical plane at right angles to its plane of oscillation are obtained by means of a heavily damped pendulum, with whose oscillations they are automatically combined on the record. Another heavily damped pendulum is used to record the tilt of the apparatus at right angles to the plane of oscillation of the principal pendulums.

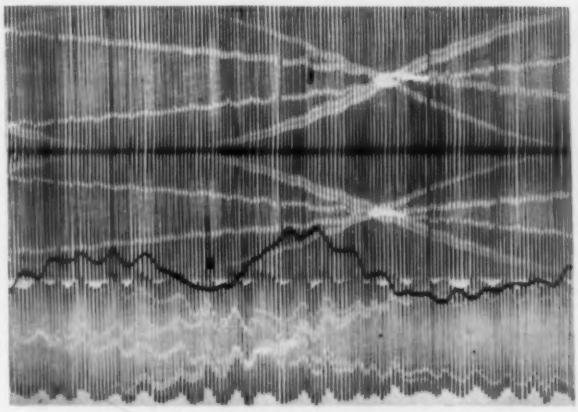


FIG. 2—Section of a typical record, taken in the Mediterranean. The upper third of the illustration shows the combined oscillations of the middle and one outside pendulum. The light streaks are the chronometer breaks. The middle third of the illustration shows the combined oscillations of the middle and the other outside pendulum. The lower part of the figure shows the oscillations of the middle pendulum referred to a vertical plane. The heavy black line indicates the tilt of the apparatus at right angles to the plane of oscillation. The temperature record is not shown in this sample.

The recording strip consists of ordinary bromide paper about $4\frac{5}{8}$ inches wide. On this strip five different records are obtained as follows (see Fig. 2). The combined oscillations of the middle and one outside pendulum; the combined oscillations of the middle and the other outside pendulum; the oscillations of the middle pendulum relative to a vertical plane; the tilt of the apparatus at right angles to the plane of oscillation; and, finally, the temperature inside the receiver.

A single light source is used. Shutters operated by chronometers interrupt the beam of light from this source for a small fraction of a second at the beginning of each second (except the fifty-ninth of each minute) of either chronometer and thus produce corresponding short

breaks in the record. These breaks permit accurate comparisons between the oscillations of the pendulums and the seconds ticks of the chronometers. When the beam of light reaches the receiver in which the pendulums swing, it is split into five parts; and these after being reflected and refracted several times are finally focused on the recording strip.

Results at Sea Stations

The computation of the isostatic reductions at the two hundred and fifty stations determined previously to 1929 has been made by the Coast and Geodetic Survey.[7] The international character of the work made possible this coöperation. The oceans of the world cover a vast area, and it is not safe to attempt to draw definite conclusions about gravimetric conditions over so large a region until we have many more stations than at present. There are, however, in the results so far obtained, some outstanding tendencies of considerable interest.

First of all, it may be stated with some assurance that isostasy exists over the oceans to almost the same complete extent that it does over land areas. It has been found, however, that our gravity formulas, which are now based entirely on land determinations, must be somewhat modified; and some account must be taken of the depression of the geoid over the oceans before a very close agreement between computed and observed values of gravity can be expected.

The intensity of gravity seems to be less than normal over the great ocean deeps. East of the Philippines the isostatic anomaly is 0.062 cm/sec^2 less over the deep than it is fifty or sixty miles away where the ocean is of about average depth. North of Porto Rico the difference of the anomalies in about the same distance is 0.228 cm/sec^2. A satisfactory explanation of these differences would be of considerable interest.

The edge of the continental shelves shows a similar tendency but in the opposite direction. On the shelf gravity is usually about normal, but in the deep water just over the edge the anomalies are positive and fairly large. The earth's crust under the wide spaces of the oceans where the depths are uniform is surely in isostatic equilibrium. Where the depth is more irregular the crust may be, and probably is, in equilibrium; but we must wait for more gravity determinations at sea before we can arrive at definite conclusions.

[7] Isostatic Reduction by the U. S. Coast and Geodetic Survey of the Results of the Pendulum Observations at Sea made in 1923 between Holland and Java, Dutch Geodetic Committee, Delft, 1926. This publication gives the isostatic results at the first thirty-two stations. The isostatic results at the remaining stations have not been published.

A POPULATION MAP OF CENTRAL OKLAHOMA FOR 1920

Clyde J. Bollinger

University of Oklahoma

THE accompanying population map of an area of 7000 square miles in central Oklahoma for 1920 is an attempt to represent both dispersion and concentration quantitatively and graphically on the same map. The symbols employed are not new. Maps on which population density is represented by contour lines or isopleths[1] are well known. B. C. Wallis employed the method in a very detailed manner to represent the distribution of population and nationalities in Austria and Hungary;[2] and the Atlas of Egypt, recently published under the direction of H. Sirry Bey, uses a similar concept to show rural population. Max Eckert discusses the use of what he calls "isarithms" for population maps in "Die Kartenwissenschaft."[3] The use of spherical symbols to represent urban population, developed by Sten De Geer[4] in his atlas of population distribution in Sweden, has also been adopted by others. For instance, Guy-Harold Smith[5] has recently used it along with the dot in making a population map of Ohio. However, the combination of the spherical symbol and the isopleth on the same map is, so far as the writer is aware, a new departure, as also is the construction of the spherical symbols by means of rubber stamps.[6]

Spherical symbols proportional in volume to the various cities and towns of the district were first entered on the map. This was done by means of a set of "globestamps" supplied, according to specifications, by a commercial stamp company. The set consists of a series of eighteen rubber stamps representing volumes ranging from .01 cubic inch to 10 cubic inches. A stamp covering an area on the map approximately equivalent to the incorporated area of

[1] On the use of this term see the note elsewhere in this number of the *Geogr. Rev.*

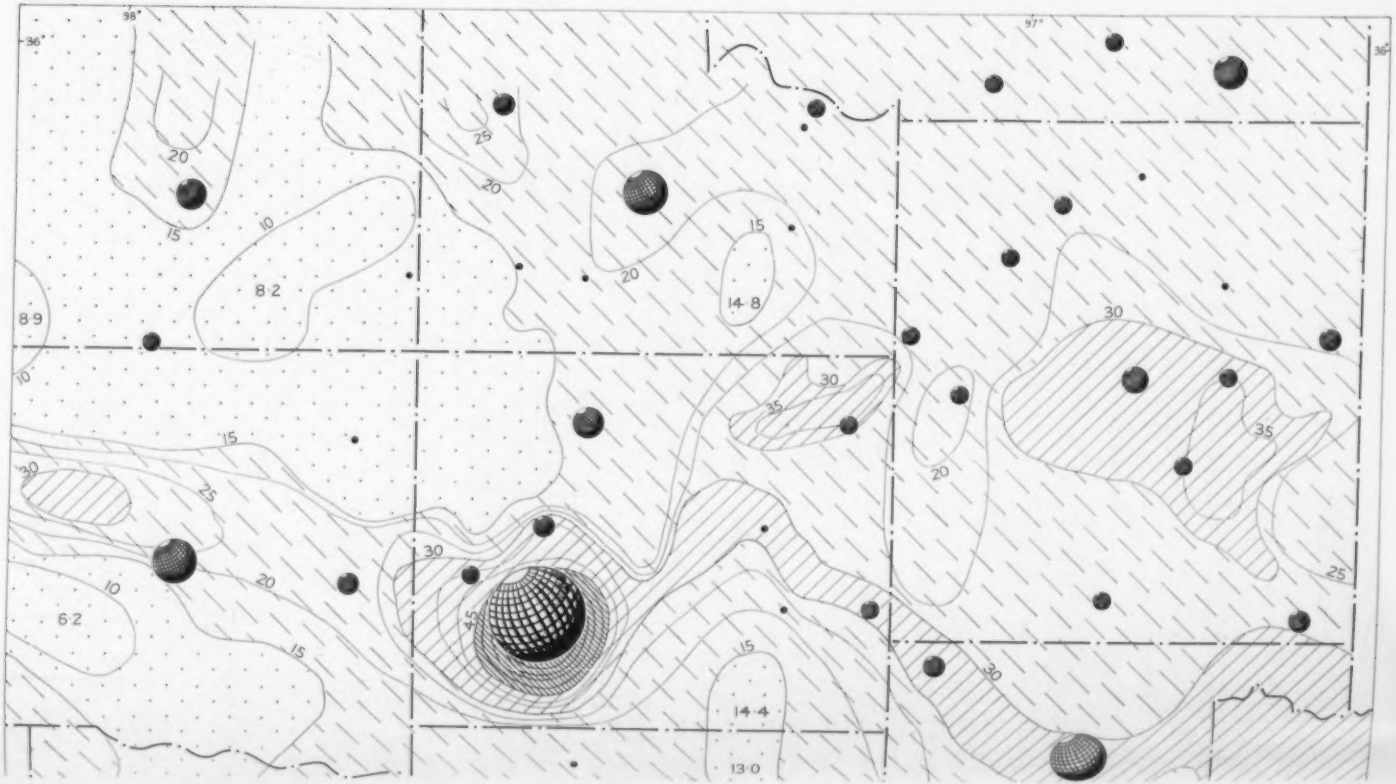
[2] Maps in *Geogr. Rev.*, Vol. 6, 1918, Pls. II, III, IX, X, XII, XIII, XV, XVI, XIX, XX. The method is explained in his paper, "Distribution of Nationalities in Hungary," *Geogr. Journ.*, Vol. 47, 1916, pp. 177–188. See also the critical comment by Wallace E. Whitehouse, "Representation of Populous Centres and Populated Areas," *Geogr. Teacher*, Vol. 13, 1925–26, pp. 90–100.

[3] Max Eckert: Die Kartenwissenschaft (2 vols., Berlin and Leipzig, 1921, 1925), Vol. 2, pp. 192–199.

[4] Sten De Geer: Karta över befolkningens fördelning i Sverige den 1 januari 1917, Stockholm, 1919. He described his method in "A Map of the Distribution of Population in Sweden: Method of Preparation and General Results," *Geogr. Rev.*, Vol. 12, 1922, pp. 72–83.

[5] Guy-Harold Smith: A Population Map of Ohio for 1920, *Geogr. Rev.*, Vol. 18, 1928, pp. 422–427.

[6] Since the stamps were devised the writer's attention has been called to a paper by S. E. J. Best, "A Method of Making Dots on Maps," *Observation*, Oxford, Summer, 1927, describing experiments in the use of a rubber stamp.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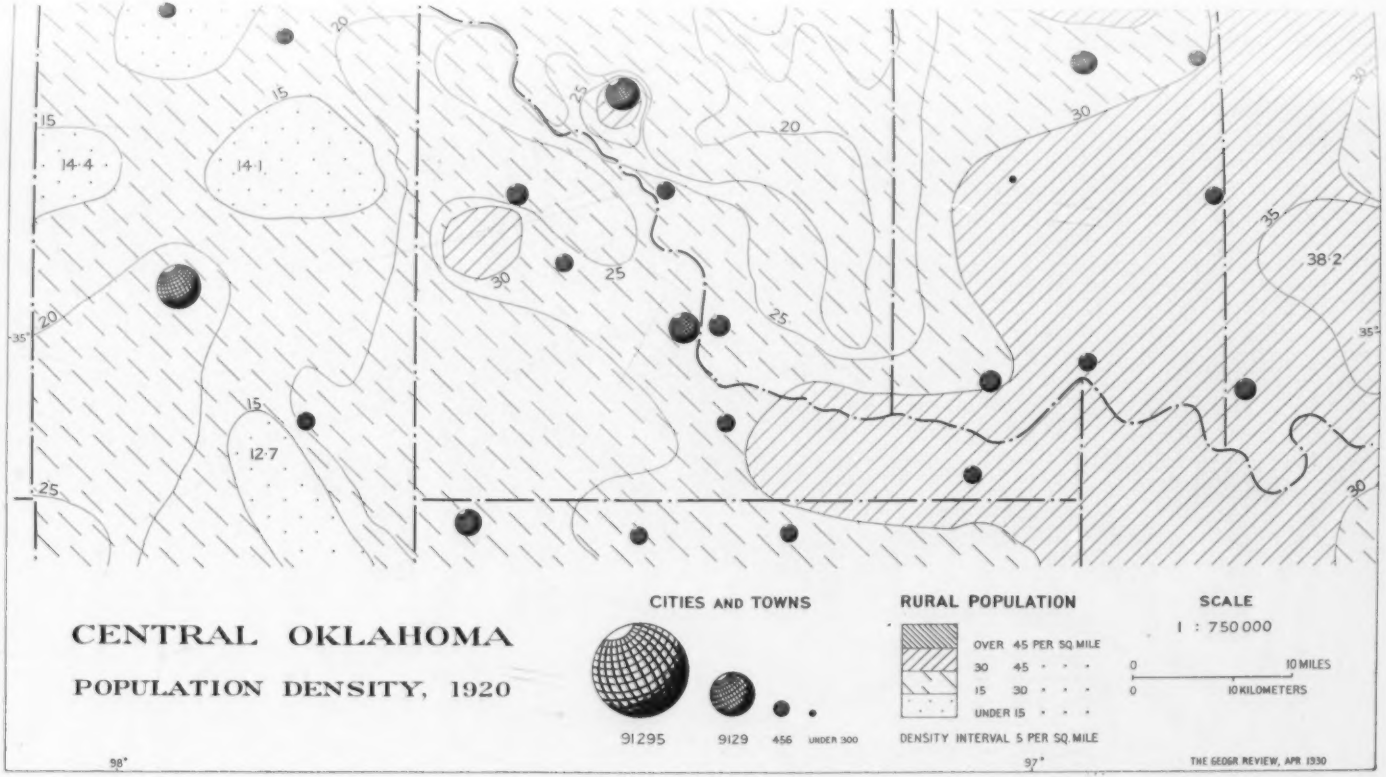

FIG. 1—Map showing population density in central Oklahoma, 1920, by isopleths and spherical symbols. The rural population was plotted by townships.

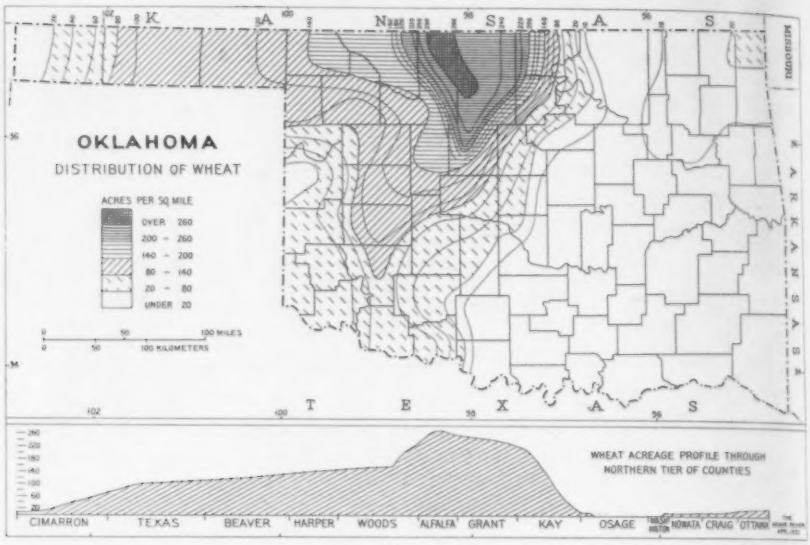

FIG. 2

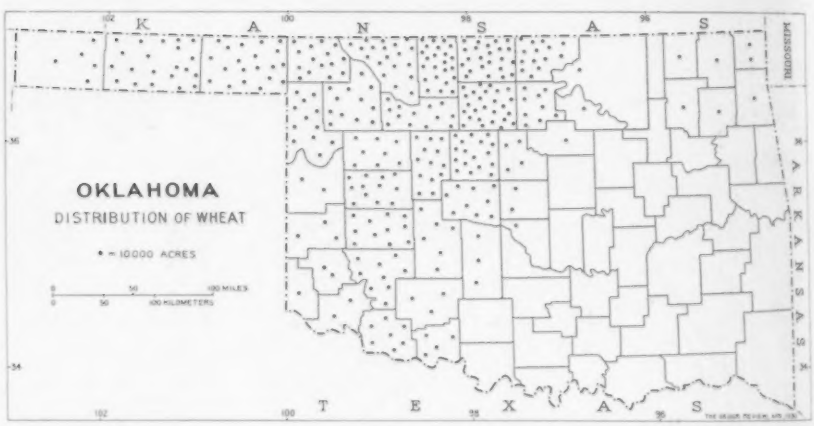

FIG. 3

FIGS. 2 and 3—A comparison of methods of showing distributional data. Wheat acreage of Oklahoma is shown in Figure 2 by the isopleth method; in Figure 3 by the dot method. The former method readily permits the drawing of "cross sections," useful in quantitative analysis.

Oklahoma City was selected to represent 91,295 people, or the number of Oklahoma City residents in 1920. The population equivalent of the other stamps of the series was then computed; and the symbols for the smaller agglomerations were stamped on the map, the stamps most nearly approximating their respective populations being used. Since symbols differing in size by less than half the interval of the stamp series cannot be readily distinguished from each other when placed on a map, it follows that the towns are represented as accurately as conditions require. The original map was on a scale of 1 : 250,000.

The charting of isopleths of rural population density was left until last so that overlap of symbols might be avoided. The density of rural population in each township was first computed and charted on the map at the exact center of area. Lines of equal density were then drawn with the same mathematical precision that is employed in constructing a rainfall or relief map.[7]

The map reveals at a glance many of the essential features of population distribution in central Oklahoma. The decrease in density from east to west associated with a decrease in rainfall, and from south to north, with the transition from cotton to wheat; the belt of denser population associated with the fertile valley bottom soils and developed transport facilities of the North Canadian River Valley; and islands of superior soils such as the Bottom Lands of the Deep Fork in the northeastern part of the area, or the inferior soils such as the "Jack Oak" sandstone hill country southeast of Oklahoma City—all appear clearly on the map. The dominance of Oklahoma City in the urban distributions is also apparent, as is the relationship between numbers of rural and urban populations. The great density of rural population in the vicinity of Oklahoma City may perhaps be taken as an indication of rapid growth and a failure to incorporate areas essentially urban in character.

The cartographic technique employed in constructing the population map of central Oklahoma is also adapted to representing the numerous other distributions for which statistical data are available. Figure 2 is an illustration. Such maps appear, when properly shaded, to be quite as graphic as the conventional dot map. Compare Figures 2 and 3. In addition, the facts represented may be described in numerical terms—which ordinarily is not possible in the case of dot maps. Cross section profiles may be drawn for quantitative comparison with the same features on different dates or with related landscape features for the same date. Preliminary maps, drawn with mathematical precision in the manner described, may be used as guides to field observation, after which revisions involving "geographic judgment" may be undertaken. Because of the peculiar adaptability of the isopleth line for representing minute areal differences, and the graphic advantages of De Geer's spherical symbol, it appears that their use together, particularly on large scale maps, has many advantages to offer. With the labor of drawing the spherical diagrams eliminated by the "globestamp" this type of map should become more common.

[7] For a discussion of the "Inclined Plane" and other methods of interpolation, see article by Robert E. Horton in the *Monthly Weather Rev.*, June, 1928, pp. 255–256.

REVIEW OF THE GEOPHYSICAL METHODS OF PROSPECTING*

Donald C. Barton and E. Buhler Summers

ADVANCEMENT in the methods of prospecting is one phase of the general increasing application of science to industry. The old-time prospector for metalliferous minerals, other than for the magnetic iron ores, had to depend on the rock exposures which he could see at the surface or could obtain in the sparsely scattered mine and prospect shafts or prospect holes, diamond drill holes, and water and oil wells. The modern prospector within the past ten years has learned to take certain very delicate physical instruments into the field and use them, as it were, to see down into the earth's crust, in some cases for miles. In the Gulf Coast of Texas and Louisiana the rich oil and sulphur deposits are associated with salt domes, which are plugs of salt a mile or slightly more in diameter intruded for 15,000–20,000 feet upward into the normal sediments; by use of these new geophysical methods, as they are called, the modern prospector can locate a hitherto unsuspected dome, determine its position, approximate limits, and approximate depths entirely in advance of drilling. In these new geophysical methods of prospecting, an explosion wave or an electric current is passed through a segment of the earth's crust, or the distant effects of certain physical properties of constituent masses of a segment of the earth's crust are measured at the surface; from the effects observed, certain conclusions can be reached in regard to the structure and mineral possibilities of the subsurface.

Although most of the geophysical methods have been in successful field use for only a few years, some one of them is used in practically every mining or oil district of the world. The brilliant successes already scored indicate great potentialities of usefulness in the future, although, like other methods of prospecting, they have their limitations.

*For a complete annotated bibliography through 1926 and for a discussion and description of all methods, see Richard Ambronn: Elements of Geophysics, transl. by M. C. Cobb (or the German original, "Methoden der angewandten Geophysik," Dresden, 1926), New York, 1928.

For a most vivid account of the extent of geophysical prospecting in North America and for a wealth of data, see C. A. Heiland: Geophysical Methods of Prospecting, Principles and Recent Successes, *Quarterly of the Colorado School of Mines*, 1929, No. 1. However, a much too optimistic impression of the success of the methods is given.

For much original material together with descriptions of the methods, see "Geophysical Prospecting, 1929," Amer. Inst. of Mining and Metallurgical Engineers, New York, 1929.

For the history of methods, see the above and also William R. Jones: Early Geophysical Prospecting, *Mining Mag.*, Vol. 40, 1929, pp. 269–272 and 348–351; Hans Lundberg: The History of Magnetic and Electrical Prospecting for Ore, *ibid.*, Vol. 41, 1929, pp. 73–78.

The exact place and the fields of special usefulness of the several methods have not yet been clearly defined. They still are rather crude; but they are improving at an accelerating rate. The use of the methods is expanding areally, in the amount of work done per company, and in the number of companies doing geophysical work. For instance, for each of the past five years more geophysical prospecting has been done in the Texas-Louisiana Gulf Coast than elsewhere in the world; and yet the work is going on there at a faster and more furious pace than ever before. The limitations of the several methods will come to be better understood, and some methods will be more used and others less used; but in general the only indication at present is of an expanding use, particularly in oil geology, for an indefinite period; favorable structures discoverable by ordinary geological methods are becoming rarer and rarer, and the pressure to find new oil fields will force an increased use of any methods that will give at least fair clues to hidden structures.

In the realms of "pure" science, the geophysical methods promise important contributions. The extensive areal torsion balance surveys by oil companies give a picture of the areal variation of gravity, whose completeness is far beyond the hopes of the geodesist. In a commercial survey with the torsion balance, the writer has followed a buried mountain system for over 100 miles, has seen it bend and take an unexpected new direction only to be chopped off and dropped to very great depths by an enormous fault. Under the apparently undisturbed sediments underlying the plains of western Texas, the torsion balance and the magnetometer have indicated the presence of what must be a large batholith circular in plan, 20 odd miles or more in diameter at least four miles high, with its crest so deep that a well centrally located went to a depth of 5000 feet without getting out of the normal sediments, and apparently basic in composition. A perennial question in discussions of the framework of this earth is where the Appalachian Mountain system goes to after it dips under the Gulf Coastal Plain; a wide areal magnetic survey by an oil company has given some important clues. Some day the question is going to be settled by the torsion balance.

Methods in Use: Gravitational Methods

The geophysical methods of prospecting in wide use today are four: gravitational, magnetic, electric, and seismic.

The fundamental theory underlying these four methods as well as the less important methods is: (1) that the presence of geologic structure or ore bodies introduces distortion into the otherwise uniform distribution of some physical property or properties; (2) that the anomalies of distribution of these physical properties in the sub-

surface may be mapped by the use of suitable instruments and methods at the surface; and (3) that from the mapped anomalies certain more or less exact conclusions or shrewd guesses can be made in regard to the geologic structures or bodies present in the subsurface.

The various theories of the geophysical methods, and even many of the instruments, were roughly worked out in many different countries long before their practical importance was realized. In fact, the practicability of the application of geophysical methods of prospecting has come to be realized only within the past decade and a half, except for the much older application of the magnetic method to the mapping of iron ores; and general recognition of the value of the geophysical methods has come only within the past five years.

The gravitational methods are based upon Newton's law of gravitation that the attraction exerted by a body is proportional to its mass. On account of the extra large, or small, attraction of an extra heavy, or light, body in the earth's crust, the intensity of gravity will be abnormally great, or small, over that body.

In the pendulum method, pendulums are used to measure the relative value of gravity in reference to the value of gravity at some base station. If enough stations are occupied, contours of equal intensity of gravity can be drawn and a picture of the subsurface obtained.

In the Eötvös torsion balance method, a torsion balance is used to map: (1) the horizontal gradient of gravity; (2) the differential curvature of the level surface; and (3) the variation of the intensity of gravity through the use of a sufficiently close net of stations and the calculation of the variation of the intensity of gravity from its gradient.

If an ore body is heavier, or lighter, than the surrounding country rock, or if heavier, or lighter, deep formations are upfolded, upwarped, upfaulted, or intruded into overlying formations, the level surface and the vertical are warped and a gravity maximum, or minimum, results. If the anomaly is above a certain minimum of magnitude, it can be mapped by the pendulum method; if it is above a certain other, usually lesser, minimum, it can be mapped by the torsion balance.

The torsion balance invented by Baron Eötvös of Hungary in 1891 was a modification of the much older Coulomb and Cavendish balances. With his gravity surveys in the Hungarian plains in the first decade of the present century, Eötvös proved the applicability of his balance to the mapping of regional geological structures. In 1917 Böckh of Budapest applied the method to the location of salt domes and other local structures with success. During the World War the Germans used the torsion balance in Rumania and Germany. Soon after the war the Anglo-Persian and Royal Dutch Shell Oil Companies started gravity surveys with the torsion balance and

did much to spread its use throughout the world. The first torsion balances were brought to America to the Gulf Coast salt dome area of Texas-Louisiana in the autumn of 1922 and were introduced into Mexico early in 1923.

The success with salt domes has been most brilliant. Before January 1, 1924, forty-two salt domes had been discovered in the Gulf Coast by geology and by accident, of which only eight had been discovered in the ten years preceding 1924. In the five years since January 1, 1924, the torsion balance has discovered six salt domes that have been definitely proved by the drill, two probably deep-seated salt domes on which commercial oil wells have been completed, two other probably deep-seated salt domes on which drilling seems to have shown some uplift although the corroboration of the doming is not definite, and a long list of untested prospective deep salt domes.

Quantitative determinations can be made of the position of the edge of the dome, of depth to the top of the cap rock, and of the amount of cap rock in the case of domes rising within 1000–1500 feet of the surface; under exceptionally favorable conditions the accuracy of the determinations is high. Buried granite, metamorphic, and massive limestone ridges such as the Nocona-Bulcher-Muenster "granite" ridge, the Amarillo granite ridge, the Healdton and Hewitt structural limestone ridges, and the faults of the Powell fault line oil fields and of the Luling oil field show up clearly in torsion balance surveys. The torsion balance together with the magnetometer have to their credit two producing structures in southeastern New Mexico. One difficulty in the western Texas Permian basin is that the torsion balance maps the structure of the basement underlying the enormously thick accumulation of sediments as well as lesser structures closer to the surface in the sediments, and that as yet the oil man is interested only in structure which to the torsion balance is relatively shallow. In the Gulf Coast the ability of the torsion balance to map deep but large structures is being taken advantage of to map salt structures that probably lie wholly below depths of 6000 feet.

The torsion balance method has its very serious limitations and uncertainties, however. The method does not have much of a field in mining. An excessively large number of stations are required to map bodies very close to the surface, and the usability of the method rapidly decreases with increase in topographic relief and in heterogeneity of the country rock; and bodies of small size can be mapped only if close to the surface. Mineral deposits rather commonly are close to the surface but are small in mass or in rough or mountainous country or are in very heterogeneous or shattered country rock. The method has been used with success with iron ore deposits in England and in delimiting the sulphur-bearing cap rock of the Gulf Coast salt domes, with indifferent success in the Tri-State lead and zinc district.

Altogether more than one hundred and twenty-five balances are at work in the United States, which is doing about one-half of the torsion balance work of the world. Outside of the United States, commercial surveys are being or have been recently made for oil in Mexico, Venezuela, Angola, France, Rumania, Italy, Hungary, Persia, the Caspian oil districts, and India; in England, Spain, and Russia for mining purposes; in Germany for oil and mining; in Japan for mining; and in Australia for oil and lignite. In Japan, Hungary, Russia, Germany, Austria, England, and on at least one of the Pacific islands torsion balance surveys have been made for purposes of pure science. About ninety-five per cent of the torsion balance work is being done by oil companies in search for oil.

The pendulum method will have no large field of practical application until its accuracy has been greatly increased. The present gravity pendulum works best on the broad major deformations of the basement; but in general it cannot map the lesser features of such major structures, in which the oil man is particularly interested, nor can it delineate the major structures as sharply as the torsion balance. The pendulum method has the further disadvantage compared with the torsion balance method that it gives no indication of the direction in which an anomaly may lie from an observation station.

The Magnetic Method

The magnetic method is based on the facts (1) that certain metallic minerals are much more magnetic than most rock masses and (2) that most rock masses and formations are faintly magnetic in differing degrees. A mineral deposit of any of the magnetic minerals in a country rock of the ordinary weakly magnetic character will produce a large magnetic anomaly. As granites and other igneous rocks, gneisses, and schists rather commonly are more magnetic than most sediments, buried ridges, fault blocks, or folds with cores of igneous or metamorphic rocks produce faint magnetic anomalies.

The following elements of the magnetic field may be measured: vertical, horizontal, or total intensity, inclination, or declination. In the mapping of the weaker magnetic anomalies associated with geologic structures, the vertical component is most commonly measured, and less commonly both the vertical and the horizontal components, for the reasons that except in low latitudes the anomaly in the vertical intensity is only faintly eccentric in position compared with the body producing the anomaly and that the vertical and horizontal magnetometers are simple and fast instruments.

The magnetic method is the oldest of the geophysical methods. Early in the seventeenth century it was used in prospecting for the magnetic ores in Sweden, and by the end of the seventeenth century a

considerable technique with a simple sundial compass had been developed; but the miner's (dip) compass was not introduced until a century later. In the middle of the nineteenth century the theory was put on a firm basis by Thalen, and more powerful instruments were devised. In America magnetic prospecting for iron ores was used first in New York and New Jersey in the latter part of the eighteenth century, and from the early seventies of the nineteenth century extensive magnetic prospecting has been carried on in the Lake Superior district. Attempts have been made to picture the effect of regional structure in the magnetic anomalies from 1846 to the present time in the United States, the Alps, Japan, Madagascar, Great Britain, Italy, Germany, and New Zealand, and in more local structures in various European countries from 1890.

The modern extensive use of the magnetometric method dates from A. Schmidt's construction in 1914 of the now extensively used Schmidt-Lloyd variometer, an adaptation of the much older Lloyd balance, and from F. Schuh's mapping of the Lübteen salt dome in Germany in 1919. The Schmidt-Lloyd balance was first introduced into this country early in 1929 by the writer working under E. L. De Golyer. Largely on account of the initial simplicity and inexpensiveness of the method, it is now widely used. The western Texas Permian basin, eastern New Mexico, many portions of Oklahoma, northern Louisiana, southern Arkansas, and portions of Kansas have been solidly mapped several times. The Gulf Coastal Plain from eastern Texas to Florida has been thus mapped by one company. Lesser amounts of magnetometric prospecting for oil and for metallic minerals have been done in many other states.

More magnetometric prospecting is being done in the United States than in the rest of the world. Venezuela stands second; lesser amounts of work are being done in Mexico, Germany, Russia, Canada, and Africa. About eighty-five per cent of the work is for oil.

The more sensitive modern magnetometers can be used for the same purposes as the older instruments and in addition for the mapping of buried granite ridges and the deep major deformations of the basement, volcanic plugs and dikes, and placer gold deposits (through the associated magnetite), salt domes, and rather exaggerated domes and anticlines, if some of the beds are abnormally magnetic. The magnetometer has been used successfully on torsion balance structures to see whether or not the structure is a simple anticlinal dome or a buried volcanic plug. The magnetometer in general maps structure less sharply and less reliably than the torsion balance. It gives better results on large-scale deformation of an igneous-metamorphic basement or on bodies of igneous rock than on structures in sedimentary rock. In prospecting for oil the results of magnetic surveys in general have been distinctly uncertain and disappointing.

Electrical Methods

The generation of natural electrical currents by certain types of ore deposits is the basis of one electrical method: other methods are based on the differences in conductivity in the uppermost part of the earth's crust. Certain types of ore deposits have a much higher conductivity than the country rock; the salt core of a salt dome has a lesser conductivity than the surrounding sediments; a fault brings up beds of one conductivity against beds of a different conductivity; a highly saline water horizon has an abnormally high conductivity. If artificial electric fields of certain types are set up in the earth's crust, the normal pattern of the electric or electromagnetic field can be calculated on the assumption that the crust is homogeneous and isotropic. The presence of a highly conductive ore body or saline horizon, a poorly conductive body like a salt core, or other disturbance of homogeneous and isotropic conductivity will produce some anomaly in the pattern of the electric or electromagnetic field actually observed.

In the self-potential method the natural earth currents generated by certain types of ore deposits of metallic minerals are utilized. The pattern of the natural field is mapped with a pair of electrodes connected by a wire through a potentiometer.

In the other methods (1) an artificially generated alternating or direct current is sent through the ground, or (2) an alternating current is sent through an insulated cable laid on the ground and used to produce induced currents in the ground; (3) a pair of electrodes with a connective wire and a suitable detecting device may be used to map the galvanic or the induced current flowing in the ground, or (4) a movable coil of wire and a suitable detecting device may be used to map the horizontal plan and dip of the electromagnetic field.

For a century attempts have been made at electrical prospecting. Experimental work was done by Fox in Cornwall, England, in 1830; by Reich at Freiburg, Germany, a little later; by Barus at Eureka in 1880; and at the Comstock lode in Nevada in 1880. Brown in America in 1900 devised a "resistance" method of prospecting. Daft and Williams, also in America, in 1902 devised a method in which an electric current was sent through the earth and the field of force set up was noted with a telephone. When the receiver records no sound, the force is at an equilibrium. This method was tried out by Petersson and Wallin in Sweden in 1906 with the result that experimentation with the electrical method continued in Sweden for ten or more years. The first new ore deposit to be discovered by electrical methods was found by Muenster in Lapland during 1907. The use of the equipotential method was introduced by Bergstrom in 1913. In Sweden, no practical method was worked out until Lundberg and Nathorst invented their surface potential method, making use of a low-frequence alternating current and electrodes of parallel cables. In France, more or

less simultaneously, Schlumberger worked with another equipotential method and devised practical field methods, making use of direct current or natural earth current and of point electrodes. In America Conklin in 1917 made the first serious experiments with the electromagnetic method; somewhat later, the Mason, Slichter, and Gauld group of physicists worked out a highly efficient field technique. Within recent years various other systems of electrical prospecting have been devised both in this country and in other countries.

Eighty-five per cent of electrical prospecting is in connection with mining. The methods taken as a whole have proved their ability to detect and outline, at least roughly, many types of ore deposits; have shown some ability in mapping certain types of geologic structures; and will probably demonstrate more ability when more application of them is made to structural mapping. They have failed as yet definitely to demonstrate their ability directly to detect the presence of oil.

The possibility of using natural earth currents to detect sulphide ore deposits has been shown in numerous mining districts of southeastern Canada, as, for example, the massive chalcopyrite-sphalerite ore bodies of the Noranda district, Quebec; the zinc, lead, and copper sulphide ores of the Sudbury district, Ontario, etc. The self-potential method does not seem to have as wide a general applicability as the other electric methods.

The resistance methods have proved their ability to map several widely different types of situations, such as the Meyenheim and Hettenschlag salt domes in Alsace (the latter an outright discovery); salt domes and anticlines in Rumania (the Boldescti anticline, a discovery); contacts between formations, as, for example, between a steeply dipping shale and sandstone in the May carbonate iron ore district of Normandy or between Oligocene and Triassic beds in fault contact at the edge of the Rhine graben in Alsace; determination of the groundwater level; mapping of the bed-rock contour under alluvium or in the glaciated regions; mapping of buried preglacial gorges at proposed dam sites.

The equipotential methods have been applied to a wide range of problems. The methods have proved their ability to map sulphide ore deposits such as the sulphide ores of the Shasta and Plumas counties, California, the pyrite-chalcopyrite ores of the Britannia Mine, British Columbia, lead-zinc sulphides of the Buchan Mine, Newfoundland. In the lead and zinc district of the upper Mississippi Valley the method showed indifferent success, indicating many of the galena deposits and also worthless marcasite enrichment, if no empty space intervened between the deposits and the surface, but not indicating the sphalerite deposits. In the arid regions of the southwestern United States these methods in general are not as successful

as in the glaciated regions on account of the great depth to which oxidation extends and, in some places, on account of difficulties with the ground water. Underground application of the methods is possible but difficult. The method has also had a slight amount of application to the mapping of structure, as, for example, mapping the strike of a fault or of steeply dipping beds. These and the electromagnetic methods have been tried out extensively in the oil regions, but results of the tests have been kept confidential.

Electromagnetic methods have been applied to about the same range of problems as the equipotential methods and have had about the same success. They have proved their ability on such sulphide ores as the lead-zinc sulphide ores of the Sudbury district, Ontario, the lead-zinc sulphide ores of the Buchan Mine, Newfoundland, and the molybdenite ores of Questa, N. Mex. They have had the same indifferent success in the lead and zinc district of the upper Mississippi Valley. They also have been applied to the mapping of salt water horizons in the subsurface for deformation of the containing beds, apparently with moderate success, and to the discovery and delimitation of salt domes without conspicuous success.

The direct determination of the presence of oil through use of an electromagnetic method has been attempted, but the ability of this or any other geophysical method to find oil directly is not generally accepted by geophysicists. Extremely high resistivity of oil "sands" is a basic assumption of most methods of the direct determination of oil. Geologically, the extremely high resistivity of oil would not seem necessarily to involve a correspondingly high resistivity of oil sands. The surveys of oil well holes by the Schlumberger method show, however, that oil sands have a resistivity somewhat higher than the surrounding sediments.

The Seismic Method

The seismic method is based upon the different rates of transmission of elastic earth waves by different materials. Artificial earth waves are produced by an explosion of dynamite. The arrival of the waves is recorded by automatic seismographs of one of two types, mechanical and electric induction. If a relatively high-speed bed underlies a relatively low-speed bed, the elastic earth waves are reflected back to the surface from the top of the relatively high-speed bed or diffracted along the surface of the high-speed bed and then back to the surface. From travel-time-distance graphs for the waves the depths, the dip, and the speed of transmission of the elastic earth waves may be determined for the relatively high-speed bed.

The relation between elastic earth waves produced naturally by earthquakes or by explosions and the geology of the earth's crust has been studied for almost a century. Before the middle of the nine-

teenth century Mallet, an English seismologist, used artificial explosions in studying the velocity of elastic earth waves in the surface formations. In 1888 Schmidt suggested using time-distance graphs to study the variation of velocity with depth. In 1902 Belar suggested applying the method to the indication of suitable places for boring tunnels. In 1907 Mintrop of Germany started work on his seismograph. His first paper on the subject was published in 1909, and others followed in 1910 and 1911. In 1912 and 1913 Galitzin of Russia, from a study of the velocity of the longitudinal and transverse waves in the formations close to the surface, pointed out that the velocity depended, to a high degree, on the physical character of the beds and that from changes in the velocity conclusions could be drawn in regard to the composition of the beds.

Fessenden was the first to apply the artificially excited elastic earth waves to the determination of local geologic structures. In 1913 in field experiments near Framingham, Mass., he developed the instrument and technique to a point of practical applicability and patented his method. By 1919 Mintrop had perfected instruments and technique to a practical stage and by 1921 had proved the potentialities of his method, which in 1923 was introduced into Mexico, and into Oklahoma and the fault line district north of Powell and the Gulf Coast of Texas in 1924. The discovery of several salt domes late in 1924 gave great impetus to the use of the method. By the spring of 1926 several workers in America had seismographs of various degrees of practicability and sensitivity.

More than fifty per cent of the seismic prospecting of the world is being done in the United States, and of the work in the United States about sixty per cent is being done in the salt dome oil field area of southeastern Texas and southern Louisiana.

The success of the application of the seismic method to the discovery of new salt domes has been brilliant almost to the point of clairvoyance. In the five years from July 31, 1924, to 1929 the seismograph has had to its credit thirty-two domes in the coastal district and six domes in northeastern Texas, which have been definitely proved by drilling, and more than twenty other domes, which have not been proved by drilling but many of which are generally accepted by geologists and geophysicists of the Gulf Coast district as authentic discoveries. A series of oil fields has been found on those seismically discovered domes.

The seismic method is being applied to the contouring of key beds and the mapping of faults and anticlines in the Gulf Coast, in eastern Texas, in the western Texas Permian basin, in Oklahoma, in Kansas, and in Mississippi and of the very deeply buried basement of the San Joaquin Valley. Whether the extremely high hopes of the consulting companies that are doing most of this structural mapping are

completely warranted is yet to be seen. It is certain, however, that the seismic method has considerable power in mapping structure and that the technique of such application is still in its infancy.

Both "mechanical" and "electric" seismographs are used successfully. The former types were used almost exclusively at first, but at present slightly more work is being done with the latter. Electric induction seismographs work as well in water, in marshland, or at the bottom of a 5000-foot well as they do on dry land. Mechanical seismographs do not work satisfactorily on marshland and cannot be used under water or down wells. One piezo-electric seismograph is in use.

An interesting application of the seismic method in "pure" science is the determination of the thickness of glacial ice. Mothes has already used the method on an alpine glacier. Wegener employed it last summer in his expedition to the inland ice of Greenland: a brief notice of the striking results obtained appears in *Die Naturwissenschaften* for February 14, 1930 (pp. 162–163).

Methods of Lesser Importance

The radio method is based on the ready transmission of the radio ether waves by electrically poor conductors and their reflection by good conductors. As the dry salt of salt domes is a poor electrical conductor, the edge of the salt or a water-bearing fissure in the salt reflects the radio ether waves. The surface of the water table in an arid region acts as a reflecting surface. The wave lengths sent out ordinarily are varied until the incoming reflected waves and the outgoing transmitted waves are in opposite phase.

The radioactive method is based on the assumption that the migration of solutions bearing radioactive minerals causes many faults to be more radioactive than the country rock; that natural gas seeps and oil seeps or springs fed from deep-seated sources may be more radioactive than normal surface rocks and waters and may indicate the presence of subsurface deposits; and that some minerals are themselves radioactive. The geothermal method is based on the tentative assumptions that, for a complex series of causes, the geothermal gradient on the crest of an anticline is steeper than normal for the general area; and that, on account of endothermic chemical reactions in which the oil is thought perhaps to take part, the temperatures of an oil field are abnormally high.

The lesser methods as yet have not had any important application. The geothermal method might have become important if other geophysical methods had not been perfected; but its indications in general must be hazy until an area has been drilled up, and for psychological reasons the method would be difficult of application in a region of competitive ownership. The radio method has a very

limited field of usefulness in salt mines and in locating water in deserts. Whether the radioactive method has any really practical application remains to be seen.

Limitations of Geophysical Methods

The geophysical methods of prospecting all have their limitations. These methods map the distribution and attitudes of certain physical properties in the subsurface. As more or less congruence exists between certain ore deposits, formations, and structural situations and one or more of these physical properties, the investigator is enabled to draw his conclusions in regard to the geological situation he is investigating.

The usefulness of a geophysical method is limited to situations in which a reasonable degree of congruence exists between the distribution of some one of those basic physical properties and the ore body or structure. The total assemblage of minerals in many ore deposits has no particular abnormal electrical conductivity, may not be abnormally magnetic, or may not have an abnormal density compared with the country rocks. In very thick, massive homogeneous formations there is little vertical variation of density or speed of transmission of elastic earth waves. Deformational structures of such formations cannot be mapped by gravitational or seismic surveys.

Geological situations other than those of interest to the economic geologist may produce distributions of the physical properties that will simulate or mask the anomalies produced by the ore bodies or structure the geologist wishes to investigate. Graphitic schists or zones of marcasitic or pyritic impregnation may be as good conductors as the ore bodies for which the geologist is looking. Irregular distribution of magnetite in the basement rocks or a depositional variation of magnetite in sediments may produce magnetic anomalies that have no relation to structure in the sediments. An abnormally dense batholith in the basement may produce a gravity anomaly that has no relation to the structures of the overlying sediments. If a 5000-foot section of sediments gradually changed from sand to limestone, a gravity anomaly would be produced which would have no relation to structure.

The size-depth relation of a body puts a certain limitation to the use of a geophysical method. There is in general a minimum-sized body which can be detected at a given depth and for a given physical situation. There is a rapid decrease in the effects of a given body with depth, if there is no change except in the depth relations. Similar bodies whose dimensions have a constant ratio in general produce effects of the same magnitude without regard to depth; but, although a large but deep structure can be mapped with the same

accuracy as one proportionally smaller and shallower, the absolute accuracy is less. Ruggedness of topography puts a limitation to the use of the torsion balance, although on certain problems and in certain situations it can be used even in mountainous areas.

The youth of the methods, inadequate geological knowledge, and erroneous preconceived ideas of the geology of the areas in which they are used all tend to impose practical limitations. The physical constants—resistivity, density, magnetic permeability; speed of transmission of elastic earth waves of hand specimens—can be determined. But the physical constants of hand specimens from the outcrops of a formation or one of the isolated samples obtainable from wells are not reliable criteria of the corresponding "geophysical" constants of the formation as a whole. Such geophysical constants cannot be evaluated until much geophysical work has been done and until the outlines of the geology of the area are known fairly accurately. As the geophysical methods are indirect methods of mapping geologic situations, a considerable knowledge of the general geologic situation and the range and degree of the geologic possibilities and probabilities is necessary for interpretation of the observed physical anomalies. But our knowledge of the geology of most areas is very sketchy; some hundred wells may have been drilled within the narrow limits of an oil field, but outside the field the wells are scattered relatively far apart. The data from them may be unreliable, and in any case few wells go below 6000–7000 feet; but commonly the torsion balance and magnetometer and, in a few places, the seismograph are "seeing" down to depths of two to three miles.

The theory of the methods has not been fully elaborated. The highly developed conventional electrical theory of electrical engineering has been worked out for the special case of homogeneous conductors of finite cross section. But the conductors with which the electrogeophysical engineer deals are of infinite cross section and commonly are more or less heterogeneous, and the theory of the behavior of electric currents in such conductors is very general. The theory of the interpretation of magnetometric, gravimetric, and seismic surveys is still in a crude state and to a considerable extent empirical; the general theory is available, but the specific theory has not been worked out for these special applications to geological situations. The mathematical theory in general has been worked out for special cases of simple geometrical form, such as the sphere or an infinitely long square or triangular prism or cylinder; but such simple geometrical forms are but rarely a reasonably close approximation to actual geologic situations.

INVENTIVENESS BY NATION

A NOTE ON STATISTICAL TREATMENT

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IN the October, 1929, number of the *Geographical Review* appeared an article by Mark Jefferson,[1] useful and suggestive, the first serious attempt to apply sound statistics to the comparison of the inventive output of the nations. His basic statistics, of patents granted in 1925 to residents of thirty-eight countries, by the twenty-six chief granting offices, can be especially useful. The object of this note is to discuss the application to them of a statistical treatment, such as the writer tried privately some years ago. As may be seen from the accompanying table the results obtained are not greatly different.

Let us begin with two of Professor Jefferson's most surprising statistical conclusions—that Switzerland leads all other countries per capita in patents taken out abroad, with ninefold the score of her nearest competitor, Sweden, and that the United States ranks twelfth, with one-nineteenth the inventive output of Switzerland. As the author says, one great reason is that the Swiss are peculiarly international-minded, so that a Swiss inventor would think at once of foreign patents, while Americans contrariwise are peculiarly insular. Another reason, which we shall not miss here, is that Switzerland is quite surrounded by industrially important countries, whereas the United States has but one such neighbor, Canada. Let us largely eliminate this disturbance by omitting from our final calculations not only patents granted in the home country, pointed out by Jefferson as necessary, but also those granted in all countries closely affiliated by common boundaries or location just across a narrow sea or by political or linguistic connection. For we find that such affiliation raises a country's score on the average 2.35-fold above the score it gets in the more remote granting offices. Another statistical fault that should be avoided is that of comparing each country's score with a variable basis "all other countries." It makes some difference whether the nation thus abstracted from the world pool be the great United States or little Switzerland. Finally, it is inadvisable to count in the colored populations of the United States and the British Dominions, since these people do not figure in invention.

In the following table we have developed Professor Jefferson's data, to grapple with the three problems last cited. First, unimportant or estimated data have been omitted. The nine chief granting offices will suffice, when grants to affiliated countries are not considered in the final figures. When used in preliminary calculations, these last have been inserted in italics. The problem of finding a fixed base, for comparative purposes, we have met by the following device: Five countries, whose names are put in italics, all of medium inventive importance and well scattered over the world, were selected. The total of grants from an office to these five is the "base" or standard unit, in terms of which the grants to any one country by that office are to be measured. For example, those five countries received from the Belgian office 455 patents, constituting the Belgian base; Belgium granted to Americans 873 patents, so 873/455, or 1.9, is set down as the score of the United States in Belgium. Doing the same for the other offices and averaging across the rows,

[1] The Geographic Distribution of Inventiveness, *Geogr. Rev.*, Vol. 19, 1929, pp. 649–661.

TABLE I—PATENTS TAKEN IN UNAFFILIATED FOREIGN COUNTRIES IN 1925

COUNTRY OF PATENTEE	OFFICES GRANTING PATENTS (WITH BASE)									PATENT SCORE	PER CAPITA PATENT SCORE	PER CAPITA RANK
	AUSTRIAN	BELGIAN	CZECHOSLOVAK	FRENCH	GERMAN	ITALIAN	SWISS	U. K.	U. S.			
	189	455	186	583	330	490	272	421	455			
Argentina	0	.0132	0	0	.0122	*.0286*	0	.0396	.0747	.0174	1.68	21
Australia	.0264	.064	.032	.125	.0758	.13	.0493	.....	*.397*	.0718	11.85	14
Austria	.....	.226	*1.005*	.217	.....	*.675*	.....	.358	.145	.234	35.81	7
3 Baltic States	0	.0022	0	0	.023	.002	.0084	.0022	0	.0047	.9	24
Belgium	.122	.....	.199	*.595*	.....	.366	.....	.....	.156	.2107	26.7	9
Canada§	.0212	.044	0	.074	.0606	.0388	.0164	.....	*	.035	4.	18
Chile	0	0	0	0	.0122	0	0	0	.0066	.0021	.56	27
Czechoslovakia	*.87*	.167	....	.34	.....	.268	.32	.342	.103	.259	18.1	11
Denmark	.069	.202	.118	.154	.....	.112	.127	.....	.132	.1306	38.	5
Finland	.0106	.0044	.016	.0275	.0242	.....	.0123	.044	.011	.0188	5.3	17
France	.55	*3.65*	1.339	.....	.....	*3.26*	.....	.....	1.19	1.0262	25.1	10
Germany†	*5.35*	*3.8*	*4.984*	*2.73*	.....	4.4	4.856†	5.†	2.85	3.62 2.32	47.	*2*
Hungary	*.37*	.083	*.193*	.074	.2272	.143	.084	.0946	.0505	.1080	12.75	13
India	.0212	.0066	0	0	.0030	.0143	0	.....	*.0066*	.0065	.02	30
Italy	*.349*	.332	.247	*.72*	.53	.....	.....	.495	.213	.3629	9.15	16
Japan	.0212	.0198	0	.0688	.0333	0	.0123	.0923	.101	.0387	.63	26
Mexico	.0053	.0044	0	0	.0151	0	0	.0044	*	.0037	.2	29
Netherlands	.35	*.518*	.290	.314	.....	.313	.431	.....	.167	.3109	41.2	4
New Zealand	0	.022	0	.127	.0122	.0265	.0041	.....	*.123*	.0127	9.4	15
Norway	.09	.089	.059	.0995	.....	.111	.107	.....	.1164	.096	36.3	6
Poland	*.0212*	.0528	*.027*	.0412	.....	.....	.0287	.02	.0066	.0298	1.1	22
Rumania	.0212	.011	*.011*	.024	.0121	.0286	.0041	.0088	.0022	.014	.81	25
S. Africa	.0212	.0044	0	0	.0121	.0061	0	.....	*.0528*	.0062	3.7	19
Spain	.0053	.0815	.043	*.233*	.0575	.157	.07	.121	.0417	.0721	3.23	20
Sweden	.248	.257	.441	.257	.....	.257	.152	.....	.343	.2792	46.	3
Switzerland	*.87*	.663	.613	*1.09*	.....	*1.19*	.....	.875	.486	.6592	167.	1
United Kingdom	.725	*1.56*	.995	*2.33*	.....	1.96	.98	.....	*2.93*	1.1649	27.	8
United States§	1.07	1.9	1.274	2.57	2.6666	2.03	1.03	.....	.....	1.7915	17.7	12
U. S. S. R.	.0053	.0132	.011	.0137	.0393	.0102	0	.44	.0066	.0599	.41	28
Yugoslavia	*.058*	.0066	.016	.0053	.0181	.....	.0246	.011	.0044	.0123	1.02	23

*Omitted because of abnormality.

†Since Germany is neighbor to all but two of the granting countries, her regular score of 3.62 was somewhat accidental, and a second score of 2.32 was calculated from all eight, deflating the neighbors. The average of the two scores, 2.97, is used in the next columns.

§The showing of the United States and Canada is much too poor; see reasons given in text.

we obtain 1.8 for the general score of the United States. This is next divided by our white population, to get the per capita score, and the national rank obtained therefrom. Affiliated countries could not be omitted from the base, but a statistical procedure was adopted, too complicated to describe here, for deflating them, so as to obtain bases equivalent from one office to another. The resulting national scores seem more rational than before, although the rank order is much the same and the spread a little greater, the coefficient of variation based on average deviation being 0.875 for the earlier calculation and 0.96 for the later.

But our methods are still open to grave exception. More years than one were desirable, to eliminate business cycles and small numbers. Adding and averaging nations is statistically objectionable—they are too disparate. The influence of domestic patent laws, which make patents so much easier to obtain or more desirable in some countries than in others, cannot be eliminated entirely by considering only the foreign patentings. For most inventors, especially in America, will think of a home patent first and, if prevented or dissuaded from taking that, will be less likely to patent their invention abroad. Again, most patent offices do not follow our American rule of requiring the application to come from the inventor but admit the owner, commonly a corporation. The statistics reflect, therefore, largely patent ownership rather than invention. Many chemical patents are granted to an international trust with headquarters in Switzerland.

As we have said, international-mindedness must be a great factor, even after affiliated nations have been eliminated. Jefferson's Table I well shows this, with Americans taking but one patent abroad to 8.2 at home, while patents to Swiss are more than half abroad, and to Belgians three to one. The United States is not only remote in distance and thought but has varied native resources and a protectionist policy that almost eliminate foreign trade (compared with domestic), and our country provides an enormous home market, enough to satisfy any ordinary inventor. Another factor in international patenting is a country's industrial type. The United States is preëminent for high wages, low interest, and large-scale production. Hence the best lines of invention for us to pursue, likely involving large, costly, labor-saving machinery, would often be of little use to patent in Germany or France, and no use at all in Spain or backward countries, except in cases where the patent would give control over a consumable product salable there. But the European countries, having work methods and also industries quite similar to one another, have strong incentives to take out other European patents. All in all, it seems likely that our statistical procedure, while leaving America but half as far below Switzerland as before, still leaves it, including Canada, so much underrated that the scores given should be taken as without significance. Between the European and backward countries our figures should be very significant of inventive output.

But now another matter. Patents are not inventions. A patent is a legal scrap of paper, which may stand for a great invention or for a little one or for nothing but foolishness or chicane. If we do not know that our various score cards on patents stand for the same grade (within limits) of invention, then we have been seeking to gather figures from thistles. Presumably the foregoing procedure, which eliminates all patents in the home and affiliated countries, does sort out a grade of inventions that are usually worth while and fairly uniform between countries. It would be desirable, however, to sift more rigorously and to check as to equality of value.

The last three columns of the table show how the countries (aside from the United States and Canada) differ. A few words as to why they differ. The sources of invention evidently lie in the great complex of modern industrial civilization. To unravel this, to find and measure the pertinent causes among the mass of concomitants and results, as by partial correlation, is a terrible task for any statistician, although my friend Barkev S. Sanders is attempting it. Comparisons between the American states are a ready approach, with their ninefold difference of patent

prolificity between Connecticut men and white Arkansans, as work done by one of my students and Professor L. J. Carr has already revealed.

Various considerations indicate race to be a strong factor, as between white and colored races. In India about half the domestic patents come from the handful of European residents: something like this is probably true of the other least inventive countries in our list. But within the white race I see no reason to doubt the ability of the so-called Latins. The Yankee race, famous for invention, is purer in Maine than in Connecticut; but the Wooden Nutmeg State takes four times the patents per capita, because it manufactures the nutmegs. It also manufactures small metal goods and copper alloys—an industrial field especially conducive to inventions and patents. Switzerland likewise is a highly industrial country, specializing in electricity, timepieces, and textiles. There is a tendency for the countries that lead in a particular field to produce not only more of the inventions in it but all the inventions; for they alone are on the skirmish line of knowledge. The rest do not need novel methods so much as they need to grow up to fit the methods invented in the more progressive countries twenty or more years before.

Professor Jefferson's explanation of Swiss superiority, by old racial selection through intelligent refugee immigrants, is attractive to a certain point and falls in with Ellsworth Huntington's findings of a proportion of eminent scientists greater there than in any other European country and almost greatest in the Swiss immigrants among all the groups in America. However, as Sanders points out, the racial factor could not operate very strongly alone. For if there were a marked surplus of some kind of ability in modern Switzerland, it would tend to depart for other lands where it would be better rewarded. A large surplus of genius could maintain itself in a land like Switzerland only by a high birth rate or by building a nest of culture specially attractive to genius, which might be expressed in scientific industries, cities, universities, etc. Apparently this is a part of the situation.

TWENTY-SIXTH ANNUAL MEETING OF THE ASSOCIATION OF AMERICAN GEOGRAPHERS

THE Association of American Geographers met at Columbus, Ohio, on December 29, 30, and 31, 1929, and January 1, 1930, for its twenty-sixth annual meeting. The sessions were held at the Faculty Club of Ohio State University, with Colonel Lawrence Martin, Chief of the Division of Maps of the Library of Congress, President of the Association for 1929, in the chair. On December 31 members of the Association were guests of the university Department of Geography and resident members of the Association at luncheon and, in the evening, at a smoker held at the Faculty Club. An exhibit of maps of Ohio, sponsored by the Department of Geography, was held in the museum of the Ohio Archaeological and Historical Society. The meeting was attended by some thirty members of the Association, both the Middle West and the East being well represented. The sixteenth annual meeting of the National Council of Geography Teachers[1] was held in Columbus on the two preceding days, December 27 and 28, and a number of Council members stayed over to take part in the all-day field excursion of December 29 and to attend the first sessions of the Association meeting. In all, exclusive of the President's address, thirty-five papers were read, of which sixteen were by persons introduced by members.

Field Studies of Urban and Rural Areas

Of the intensive studies of local areas that have formed the most distinctive contribution to the program of the Association meetings during the last few years (see especially report on the Twenty-Third Meeting, *Geogr. Rev.*, Vol. 17, 1927, p. 310) there were six, five dealing with urban centers and one with rural type areas. A. E. Parkins under the title of "Nashville: A Study in Urban Geography" dealt with the business section, especially the retail district, of that city. By means of maps and a series of profiles drawn to scale of the buildings along the main commercial streets showing the various uses to which the buildings are put he undertook an analysis of the factors influencing the migration of business districts. The technique, although avowedly experimental, showed that in the investigation of such problems the geographical method has something to contribute that is not provided by methods customarily used in making economic surveys. Preston E. James's paper, "Vicksburg: A Study in Urban Morphology," illustrated by a large-scale use-classification map, discussed the growth of the city. An interesting point is that the part of the city originally laid out as the town center never became the real functional nucleus. In addition to this man-made handicap nature delivered a severe blow when, in 1876, the Mississippi shifted its main channel and left the city fronting on an abandoned meander.

Using an ancient term in a sense somewhat different from its original connotation D. S. Whittlesey spoke on the "Chorography of the Boston District." The results of this experimental application of the reconnaissance method to urban geography provided an excellent first general survey, suitable for filling in by later more intensive studies, of the roughly concentric arrangement of Boston's use areas literally around its Hub. Robert S. Platt's paper on "Marquette, Michigan: An Urban Field Study"

[1] "The Columbus Meeting of the National Council of Geography Teachers," *Journ. of Geogr.*, Vol. 29, 1930, pp. 70–76.

was a sequel to his paper on Republic given two years before at the Nashville meeting. Like this other study of a small Upper Peninsula community it was based on quantitative data and detailed maps and aimed "to focus attention . . . on the occupancy of land by groups of people and on the pattern of these activities woven to fit the environmental background." In "The St. Paul-Minneapolis Double Railroad Center" Richard Hartshorne pointed out that the Twin Cities, whose nuclei are 10 miles apart by air line and 15 miles by river, are two cities in a single urban area, not two "half cities," like Kansas City, Kan., and Kansas City, Mo., nor is one the satellite of the other. This duality, dating from pre-railroad days, has, if anything, been strengthened and perhaps perpetuated in the railroad era.

The paper in this group that dealt with rural areas was presented by Professor R. B. Hall (introduced) of the Department of Geography of the University of Michigan under the title "Some Rural Settlement Forms in Japan." Three types were discussed: the Yamato Basin type (about Nara, east of Osaka), in which the villages are so compact that they seem detached patches of an urban unit; the Satsuma type (southwestern Kyushu), in which the house form with the thatched roof extending beyond and below the floor platform to the ground bespeaks location in the typhoon belt; and the Echigo type (about Niigata), characterized by the most extensive *strassendorf* development in Japan.

Climatological Studies

Of seven papers read on climatological topics four represented contributions from the School of Geography of Clark University. Charles F. Brooks, in continuation of his studies of the influence of changes in the temperature of the Gulf Stream on the weather of the Atlantic Coast of the United States, a line of investigation first broached by him at the Baltimore meeting of the Association in 1918, reported on "Gulf Stream Daily Thermograms Across the Straits of Florida." The observational material in this critical area had been gathered on many steamships plying between Key West and Havana and equipped with specially designed thermographs. Two advanced students (introduced), Edna M. Fitton and J. L. Page, spoke respectively on "The Climates of Alaska" and "Temperature and Temperature Provinces of Mexico." Both papers culminated in a subdivision into climatic provinces of the region in question. C. E. Koeppe (introduced) discussed "Some Phases of Climate in the Canadian Spring Wheat Belt," defining the area as within the 58° F. mean summer isotherm. No account was taken of Unstead's fundamental paper on the climatic limits of wheat cultivation, especially in Canada, that was published in Volume 39, 1912, of the *Geographical Journal*. S. S. Visher, in "Evidences as to the Frequency, Intensity, and Causes of Weather Changes in Tropical Regions," pointed out that, as a result of the concentration of interest on tropical hurricanes, the normal tropical lows and their influence on the weather of wide areas have not received from meteorologists the attention they deserve. G. D. Hubbard's paper, "Oberlin's Peculiar Spring Weather," dealt with a detail of local climate probably attributable to the fact that the low cloud blanket that frequently hovers over Lake Erie (elevation, 573 feet) at that season abuts on the Lake-Gulf divide (summit, over 1100 feet), creating overcast weather for the lake-slope communities underneath.

A suggestive and thoughtful paper entitled "A Quantitative Classification of Climate" was presented by C. W. Thornthwaite (introduced) of the University of Oklahoma. Like the work of Leighly, Van Royen, and R. J. Russell it represented an outgrowth of the recent revival of interest in Köppen's world classification of climates and its local refinement for parts of North America. Carrying forward the recognition of the need for greater emphasis on evaporation voiced by Transeau, by Eric McDougall, and by Livingston and Shreve, Thornthwaite developed an

experimental formula expressing the ratio of precipitation to evaporation in terms of temperature and precipitation. Applying this formula to the data available, he produced a map of the United States showing isopleths of precipitation *effectiveness*. The close correlation of this map with the known distribution of vegetation, especially in the Cordilleran section, seems to indicate that the method employed represents a real contribution.

Vegetation and Other Aspects of Physical Geography

The Department of Botany of Ohio State University has long been known for its valuable work in the plant geography of the United States. Professor E.N. Transeau of that department, one of the resident members of the Association, gave two papers, one entitled "Rainfall Types of the Plains, Prairie, and Forest Regions," the other "Progress in the Survey of the Vegetation Types of the East Central States." The first paper was illustrated by a number of climatic diagrams of places in the region in question, which went to confirm the independent identity of the tall-grass prairie, an identity that has recently been questioned. In the author's view the tall-grass prairie will always exist as an entity between the (short-grass) plains and the forest although it may shift with climatic change. The second paper presented the tentative results of systematic field studies, pursued in the region since 1916, in the form of three maps of the original vegetation types: one of Ohio by E. N. Transeau and H. C. Sampson, one of Indiana by R. B. Gordon, and one of the Ohio-Upper Mississippi Basin, incorporating and expanding the other two maps. The methods followed in the detailed field studies were explained with regard to a sample area by H. C. Sampson (introduced) under the title of "Vegetation Types and Soil Types in Marion County, Ohio."

Other aspects of physical geography were represented by a paper by Mark Jefferson dealing with conditions following three years of unusually heavy rainfall in 1926–1928 (see his "Variation in Lake Huron Levels and the Chicago Drainage Canal," *Geogr. Rev.*, Vol. 20, 1930, pp. 133–137), and by two papers by R. H. Sargent describing the recent aerial mapping undertaken by the U. S. Geological Survey with the aid of the Navy and other Government departments in the Alaska panhandle and illustrated by remarkable oblique and vertical photographs of glaciers taken from the air. The view of La Pérouse Glacier disclosed the fact that the present glacier may override an underlying glacier and moraine. An excellent physiographic paper by S. N. Dicken (introduced) of the University of Minnesota dealt with "Kentucky Karst Landscapes" in terms of Cvijić's classification.

Economic Geography

Seven papers dealt with subjects specifically belonging to economic geography. F. E. Williams discussed the iron and steel industries of the Schuylkill Valley, Pennsylvania, with the aid of a series of maps showing the distribution of iron forges and steel plants from the middle of the eighteenth century to the present. The same industry in the district of Youngstown, Ohio, was described by Langdon White (introduced) of Randolph-Macon College, who pointed out the relationships of the Mahoning Valley industrial district, located on a main transportation route between the Appalachian coal field and Lake Erie, yet handicapped by its relatively land-locked position. R. H. Whitbeck called attention to a salient example of two areas similarly endowed by nature undergoing a divergent development owing to the introduction of an artificial economic factor in the case of one—Jamaica, prosperous through its untrammeled banana production as compared with poverty-stricken Porto Rico, its main source of wealth undermined by the sugar tariff. J. F. Bogardus (introduced) of the University of Pennsylvania dealt with "Recent Production and Movement of Coal in Western Europe." The paper discussed the

surplus coal-producing capacity of the various relevant countries of Europe which has been brought about by the post-war intensification of producing power, matched by little or no increase in consumption. This surplus is estimated at about one-quarter in Germany, from one-quarter to one-third in the United Kingdom, and about one-half in Poland. Helen M. Strong, in a paper entitled "The Geography of a Foreign Investment," discussed the need for geographical, especially regional, knowledge in connection with any enterprise involving financial investment in a foreign country.

K. C. McMurry spoke on "Use of Land for Recreation" and pointed out that maintenance of the traditional exploitation in terms of agriculture and forestry is not the best solution of the problem in the case of certain types of land, such as those of northern Michigan. The very factors that act as a disadvantage if the land is to be used for agriculture become an advantage if it is turned to recreational purposes. Among these use for hunting has become of importance to Michigan. The income to the state from licenses—400,000 were issued during 1929 for small game and 70,000 for deer—and the food value of the game, which is increasing in numbers under proper protection, to the people of the state are appreciable. R. G. Buzzard (introduced) of the Illinois State Normal University at Normal, Ill., dealt with a minute item, the production of a certain type of lawn seed in southeastern Illinois.

Human and Regional Geography

H. M. Leppard (introduced) of the Department of Geography of the University of Chicago discussed the "Settlement of the Peace River Country" of the Canadian Northwest. The paper was an outgrowth of observations made on the advanced field course of the department during the summer of 1929, a course inspired in part by the Canadian Pioneer Belts undertaking sponsored by the Social Science Research Council and initiated by the American Geographical Society (see *Geogr. Rev.*, Vol. 19, 1929, p. 320). The district primarily being settled extends from Lesser Slave Lake westward to include the basin of the Peace River in its east-west segment in latitude 56° N. In 1916 the population was about 9000, in 1926 20,000; and in the nineteen months between January 1, 1928, and July 31, 1929, homestead entries and other land grants totaled about 10,000, which may be assumed to represent an additional new population of about 30,000 (population distribution was illustrated by dot maps for 1911, 1916, 1921, 1926). Although the region is of great promise, settlement, in the author's view, may have been overstimulated. When a farmer has cleared his land he often finds that the 160 acres allotted to him are too small for economical exploitation. The resulting tendency of farmers to move on has led to a "grasshopper" method of settlement. D. R. Bergsmark (introduced) of the University of Cincinnati reported on the results of a geographical survey of Clermont County, Ohio, an agricultural area east of metropolitan Cincinnati.

An interesting paper entitled "The Kishacoquillas Valley," by Henry F. James (introduced) of the Wharton School of the University of Pennsylvania, read by Professor J. H. Willits of the Wharton School, dealt with the life of the "Amish" Mennonite sect of Pennsylvania Germans inhabiting the canoe-shaped anticlinal valley of that name (in Mifflin County, central Pennsylvania) and the forces tending to break down their isolation. Stanley D. Dodge discussed "The Distribution of Population in Connecticut" by means of a large-scale dot map of the state (one dot to 1000 inhabitants according to the 1920 census) and traced the origin of the various belts of population that the map primarily disclosed. The predominance of manufacturing-town foci in western Connecticut was attributed to the fact that the main New York-Boston traffic routes with their northward swing in the Connecticut Valley traverse that part of the state; also, the population that might otherwise live in eastern Connecticut is drawn off by industrial Rhode Island. G. B. Cressey

(introduced) of Harvard University, lately of Shanghai College, spoke on "The Geographic Regions of China," illustrating his remarks with an original map of the natural regions of China—a revised version of the map in his mimeographed "Geography of China," 3rd edition, Shanghai, 1928—with tables showing for each natural region the area, population, population density, amount of cultivated land, percentage of total area in cultivated land, etc.

The field excursion on December 29 may be considered as falling under the head of local regional geography. Before the excursion the leader, Professor Roderick Peattie of the Department of Geography of Ohio State University, gave an account of the geography of Columbus and its environs. An excellent booklet on the same topic entitled "Columbus, Ohio: A Geographic Analysis of a City's Development," edited by himself and containing contributions by various members of the department and others, was distributed to those in attendance. The party was transported in motor buses. Type areas, industrial, business, and residential, were traversed within Columbus itself; and the route then made a wide circuit around the city, partly along the Scioto River and the water-supply reservoirs along it, passing at one point one of the prehistoric mounds prevalent in the region.

Mathematical and Historical Geography

Two papers dealt with the application of mathematics to geography. Mark Jefferson presented "A New World Map for Continental Data." This consisted of a non-continuous net based on the projection of a movable spherical quadrilateral representing a sixth of the earth's surface shifted in each case so as to frame the continent to be shown. F. A. Carlson (introduced) of the Department of Geography of Ohio State University spoke on "Geographical Index Numbers" and presented a formula intended to make it possible numerically to determine where, in a scale of digits in which 100 represents the optimum, the human utilization of a given region stands. W. L. G. Joerg read a paper on "The Significance of Bellingshausen's Antarctic Voyage of 1819–1821," in which Bellingshausen's expedition (field seasons of 1819–20 and 1820–21) was discussed on the background of the 1772–1773, 1773–1774, and 1774–1775 Antarctic voyages of Cook, whose work Bellingshausen designedly supplemented and expanded. The first complete English translation, so far as known, of Bellingshausen's account of his meeting with Captain Nathaniel B. Palmer of Stonington, Conn., was presented and compared with Fanning's account of the American version of that incident of importance in the history of American Antarctic exploration.

To the field of historical geography belonged also the President's address at the annual dinner on December 30. In the address, entitled "The Michigan-Wisconsin Boundary Case in the Supreme Court of the United States in 1923–1926," he discussed, often with the light touch they deserved, the numerous complications resulting from this recent classical example of the need for a closer reconciliation of science and jurisprudence. The various segments of the boundary were discussed seriatim, the address culminating in an exposition of the ambiguity left by the court decision as to the final stretch where it passes out of Green Bay into Lake Michigan between islands continuing the Door Peninsula. The address was illustrated by a number of historical maps and large-scale enlargements of the different sections of the boundary, all arranged and mounted together to form one large wall map.

AMERICAN GEOGRAPHICAL SOCIETY

December Meeting and Award of the David Livingstone Centenary Medal for 1929 to Rear Admiral Richard Evelyn Byrd. The regular monthly meeting of the American Geographical Society was held on December 19, 1929, at the Engineering Societies' Building, 29 West 39th Street, President Finley in the chair.

After calling the meeting to order President Finley announced the award of the David Livingstone Centenary Medal for 1929 to Commander (now Rear Admiral) Richard Evelyn Byrd. The medal, founded by the Hispanic Society of America, is awarded by the American Geographical Society "for scientific achievement in the field of geography of the southern hemisphere." The Society has had a special interest in Admiral Byrd's Antarctic expedition, making a contribution to it and assisting in the formulation of the scientific plans. The Society has been in close touch with the expedition throughout and is satisfied as to the very great value of the scientific results achieved (see this number of the *Geographical Review*, pp. 333–334, and the January *Review*, pp. 150–151). The new technique introduced through aerial mapping and constant communication by radio places it in a unique position among polar expeditions, as will be fully apparent when the scientific material is worked up and the results laid down in detail on the map.

Admiral Byrd, notified of the award for his brilliant work in Antarctica, thanked the Society by radiogram in the name of the expedition and said in conclusion, "Whatever we have been able to accomplish has taken the wholehearted coöperation of every man, and so I accept this honor in the name of the Expedition and thank you most sincerely." Presentation of the medal will be made on a special occasion after Admiral Byrd's return.

President Finley then introduced the speaker of the evening, Dr. A. V. Kidder, lately appointed Director of the Department of Historical Research in the Carnegie Institution of Washington, who addressed the Society on "An Air Reconnaissance of the Maya Country." Dr. Kidder accompanied Colonel Lindbergh in a series of flights made in October, 1929, over the jungle regions of Central America in which are located the principal cities of the ancient Maya civilization. During these flights several sites, presumably new, were located and a wealth of information on the physical character of the country was obtained—the necessary background for formulating plans for an air survey of Central America. An account of the expedition by Dr. Kidder and Mr. Ricketson appears in this number of the *Geographical Review*.

The January Meeting. The Annual Meeting of the Society was held on January 21, 1930, at the Engineering Societies' Building, 29 West 39th Street, President Finley presiding. The Annual Report (printed below) was read and the officers for 1930 elected.

Dr. Finley prefaced his introduction of the lecturer by the formal presentation of a globe showing the routes followed by the principal fliers up to the present time together with their signatures. He referred to this globe as his most highly prized possession and stated that he regarded it as probably the most valuable globe in the world at the present time; under ordinary circumstances it would be extremely hard to part with so dear an object, but he did so with great pleasure, knowing that the American Geographical Society was the best place for it.

On behalf of the Society Mr. Greenough received the globe and in a charming speech of acceptance stated that the gift would always be associated with the name of the giver and appreciated as a unique contribution to the history of exploration

by air. In concluding, he dwelt on the contribution of the *New York Times* to exploration and expressed the Society's appreciation of the work of that newspaper, to which he wished to take opportunity to refer in a complimentary manner while thanking Dr. Finley for his splendid gift.

Mr. F. A. Mitchell-Hedges thereupon delivered a lecture entitled "Land of Wonder and Fear," dealing with the country occupied by the Chucunaque Indians of Darien, a primitive tribe of unusual interest.

February Meeting and Presentation of the Cullum Geographical Medal for 1930 to Curtis Fletcher Marbut and of the Charles P. Daly Gold Medal for 1930 to Nelson Horatio Darton. The regular monthly meeting of the American Geographical Society was held on February 25, 1930, at the Engineering Societies' Building, 29 West 39th Street, Honorary President Greenough in the chair. The first part of the proceedings was devoted to the presentation of the Society's medals.

The Cullum Geographical Medal for 1930 was awarded to Curtis Fletcher Marbut. In presenting the medal Mr. Greenough said: "As our Fellows are aware, the Society is devoted to the policy of research, that is, an effort to add to the volume and improve the quality of existing knowledge, and its honors are conferred for achievement in every branch of geographical science. Dr. Marbut has rendered essential service to his country in his labors, to use the famous phrase of Dean Swift, for making 'two blades of grass grow where only one grew before.' " Some idea of these labors may be obtained from the following brief résumé.

Dr. Marbut is Chief of the Division of Soil Surveys of the U. S. Department of Agriculture and has carried out field studies of wide scope. In 1923–1924 he was engaged in investigations in the Amazon Basin as a member of the Crude Rubber Survey of the U. S. Department of Commerce. He took an active part in the organization of the First International Congress of Soil Science, held at Washington, D. C., in 1927, acting as chairman of the commission on classification, nomenclature, and mapping of soils. As president of the Association of American Geographers he delivered an address before that body in 1924 on "The Rise, Decline, and Revival of Malthusianism in Relation to Geography and Character of Soils."

Mr. Greenough thereupon handed the medal to Dr. Marbut with the citation: He has plowed a deep furrow in the virgin field of soil geography. By his skillful application of the philosophy and principles of modern science to the classification and mapping of soils he has given new direction to man's conquest of nature—the better utilization of that precious heritage, the soil, "foothold of all things."

In responding Dr. Marbut spoke of the smallness of any one individual's contribution in the vast field of science, albeit the opportunity to make that contribution was a reward in itself to the worker, and of the dependence of all discoveries on the work that had gone before.

The Charles P. Daly Gold Medal for 1930 was awarded to Nelson Horatio Darton. In presenting the medal Mr. Greenough referred with appreciation to the steadily maintained work of the government bureaus, whose services the public at large is perhaps apt to overlook. "One of the oldest and most important of these is the U. S. Geological Survey, and the intimate relation of this bureau to geographical science is well illustrated in the work of Nelson Horatio Darton. He has been connected with the Survey since 1886 except for the period 1910–1913, when he was associated with the Bureau of Mines. He has conducted researches in the geology and mineral resources, the topography and water supply of our western lands. He has written an excellent monograph on the Big Horn Mountains. His surveys in the peninsula of Lower California have been incorporated in the American Geographical Society's Millionth Map of Hispanic America."

Mr. Greenough thereupon handed the medal to Dr. Darton with the citation: His preparation of the topographic base maps of Arizona and New Mexico on the

scale of 1:500,000 proclaim him a worthy follower in the great tradition of the surveys "west of the 100th meridian." With great energy and continuity of purpose he has carried forward researches in the physical geography of our western domain from its northern to its southern borders and beyond, laying foundations for the fuller enjoyment of its resources.

In responding Dr. Darton said that although he had covered a large area in his surveys much of his work was of an essentially reconnaissance nature, and he pointed out that great areas of our west are still virgin territory to the scientist.

The meeting was then addressed by Mr. R. H. Sargent of the U. S. Geological Survey on "Alaskan Glaciers From the Air." Mr. Sargent exhibited and described a selection of the aerial photographs made by the Navy Department in coöperation with the Survey and other Federal services as part of the government program in Alaska. Among the magnificent photographs was a series of special interest illustrating features of glacier flow.

Elections to Fellowship. At the December and January meetings of the Society, President Finley presiding, and the February meeting, Honorary President Greenough presiding, there were presented with the approval of the Council the names of 212 candidates who were duly elected as Fellows of the Society.

Presentation of the Charles P. Daly Gold Medal for 1930 to Joseph Burr Tyrrell. The celebrations attending the inauguration of the Canadian Geographical Society (see pp. 341–342 of this *Review*) were made the occasion by the American Geographical Society for the presentation of the Charles P. Daly Gold Medal for 1930 to Mr. J. B. Tyrrell, the distinguished Canadian geologist and geographer. Presentation was made at a luncheon at the Rideau Club, Ottawa, on January 17. The officers and directors of the Canadian Geographical Society were in attendance and heartily endorsed the Society's choice for the award. Dr. Isaiah Bowman, Director of the Society, in making the presentation spoke in part as follows:

"It gives me very great pleasure to meet the directors of the Canadian Geographical Society and to have the opportunity of presenting an honor to one of your members. If one looks through the records of exploration in Canada there is one name of peculiar merit and distinction. It is that of Joseph B. Tyrrell, whom you have placed at the head of your organization as Honorary President.

"His name is known to scholars everywhere. One finds it on the title pages of two great volumes on Hearne and Thompson published by the Champlain Society. The annual reports of the Geological Survey of Canada contain many substantial scientific contributions by him.

"His canoe has been beached at innumerable camp sites on many of the great rivers of the north and northwest from Hudson Bay to the Yukon. To record the marks of his geological hammer would require a map of much of Canada. While the Geological Society of London, in 1918, granted him its Murchison medal, it is as a geographer and explorer that we hail him today.

"To you, Sir, seeker of gold deposits in many a distant outcrop, there comes by the processes of science and art a piece of that rare metal stamped on one side with the design of a ship under full sail and on the other with a rugged steersman standing to the wheel. These symbolize the courage and fidelity you have shown in your explorations in Canada; they are emblems which harmonize with your record of past years and with the honored place assigned you in this new Society.

"In presenting you with the Charles P. Daly Gold Medal of the American Geographical Society of New York, I take occasion, on behalf of the Council of that institution, to acknowledge the indebtedness of geographical science to your labors of the past and to wish you many more years of achievement and happiness."

In responding, Mr. Tyrrell referred to the progress in exploration and settlement in northern Canada. He contrasted methods of his early days with the swift develop-

ments of today that point to the fulfillment of a prediction made by him three decades ago (see *Dawson Daily News*, January 1, 1901)—that the twentieth century would be Canada's century. And of it the foundation of the Canadian Geographical Society is a happy augury.

Award of the Cullum Geographical Medal for 1929 to Hugh Robert Mill, Jean Brunhes, Alfred Hettner, Jules de Schokalsky. The Cullum Geographical Medal is awarded from time to time to those "who distinguish themselves by geographical discoveries, or in the advancement of geographical science." The last awards were made in 1925.

HUGH ROBERT MILL. Geography is under a heavy debt to Dr. Mill for researches in his special field and writings on a wide range of geographical topics, all resting on a sound physical basis. As he himself has expressed it, his researches have been largely directed towards the discovery of the control exerted by the various forms of the earth's solid crust upon the fluid envelopes. Dr. Mill was Director of the British Rainfall Organization and editor of *British Rainfall* and *Symons's Meteorological Magazine* for many years. He has filled various offices in the Royal Meteorological Society and the Royal Geographical Society and has served on the International Council for the Study of the Sea.

Educational geography has profited from his writings; and he has always had a special interest in the polar regions, particularly the Antarctic. He is Chairman of the Board of Directors of the Captain Scott Polar Research Institute.

JEAN BRUNHES. The name of Jean Brunhes, professor of geography at the Collège de France is one with "La géographie humaine," one of the outstanding geographical works of our time. Translated into English it has had a profound effect upon American geographical teaching and point of view. Professor Brunhes is also known for his volume on the human geography of France contributed to the "Histoire de la nation française" and his collaboration with Camille Vallaux on the "Géographie de l'histoire." The government of France has sought his advice and assistance in studies and recommendations relating to the French colonies in the Far East and in Africa.

ALFRED HETTNER. As professor of geography in the University of Heidelberg, Dr. Hettner has exercised great influence on the development of geography in Germany, especially regional geography. In this he has been particularly aided by the *Geographische Zeitschrift*, one of the leading critical geographical journals, of which he is founder and editor. As a young man Hettner carried out important explorations in South America. "Russland" and the "Grundzüge der Länderkunde," to mention two of his numerous writings, are model works of their kind, and a special word must be reserved for his book on methodology.

JULES DE SCHOKALSKY. Dr. Schokalsky is professor of oceanography in the Leningrad State University, President of the Russian Geographical Society, and Corresponding Member (Meteorology) of the Russian Academy of Sciences. His voluminous writings have been mainly in the fields of oceanography, hydrography, and cartography. In the last named he compiled what is now the standard general map of Russia, a map in 16 sheets on the scale 1 : 2,000,000. In 1917 he published a treatise on oceanography which is the crystallization of his previous work along these lines. He has recently undertaken a comprehensive survey of the Black Sea.

Award of the Charles P. Daly Gold Medal for 1929 to Filippo De Filippi and Émile Félix Gautier. The Charles P. Daly Gold Medal is awarded from time to time "for valuable or distinguished geographical services or labors." The last award was made in 1927.

CAV. FILIPPO DE FILIPPI, Secretary-General of the International Geographical Union, has done distinguished work in exploration. He accompanied the Duke of the Abruzzi on expeditions to Mt. St. Elias, in the Karakorum, and to Mt. Ruwenzori. Realizing the "variety and the importance of the problems as yet unsolved" in the Karakorum region, he organized an expedition of his own in 1913 and by the aid of a group of specialists carried out some remarkable work in geology, physical geography including glaciology, and human geography in the mountains and plateaus between the Vale of Kashmir and Chinese Turkestan.

ÉMILE FÉLIX GAUTIER. For a quarter of a century Professor Gautier, of the University of Algiers, has devoted himself to geographical investigations in northern Africa and the Sahara, on which regions he is a recognized authority. His writings, distinguished by characteristic ease and originality, reveal the intimacy of his knowledge in his chosen sphere.

Election of Honorary and Corresponding Members. At the meeting of the Council of the American Geographical Society held on January 16, 1930, notable addition was made to the membership list of the Society in the election of Honorary and honorary Corresponding Members. No elections to the former class have been made since 1922 nor to the latter class since 1925.

HONORARY MEMBERS

ALFREDO JAHN of Caracas, Venezuela, has made important contributions to geographical knowledge of the country of his adoption. He carried out the original reconnaissance studies for most of the railways of Venezuela. He has been engaged for many years, under the auspices of the government or on his own initiative, in geographical and geological surveys in northern Venezuela.

SIR NAPIER SHAW is the distinguished investigator of the air and its ways. His name is associated with the recent great developments in that science, especially in connection with the exploration of the upper air, and with their human applications. He was for many years Director of the Meteorological Office, London, and has worked ardently for the advancement of meteorological studies, both national and international.

HUSSEIN SIRRY BEY is Surveyor-General of Egypt. Under his direction the admirable "Atlas of Egypt" was prepared as Egypt's contribution to the International Geographical Congress held at London and Cambridge in 1928.

CORRESPONDING MEMBERS

ROBERTO ALMAGIÀ is professor of political and economic geography at the University of Rome. His geographical interests are broad—ranging from physical and human studies, especially of Italy and other Mediterranean countries, to investigations on the historical side, especially early Italian cartography. He is one of the editors of the *Rivista Geografica Italiana* and secretary of the Società Italiana per il Progresso della Scienzia.

HENRY BRYANT BIGELOW is research curator in zoölogy, Museum of Comparative Zoölogy, Harvard University. He is chairman of the North American Committee on Fisheries Investigations and scientific adviser to the International Ice Patrol. For many years he has been engaged in an oceanographic and biologic survey of the Gulf of Maine.

CARL BEN EIELSON was Captain Sir Hubert Wilkins' chief pilot on his Arctic expeditions of 1927 and 1928 and his Antarctic expedition of 1928–1929. In this

capacity he shared the 500-mile flight northwest of Point Barrow in 1927, the epoch-making flight from Point Barrow to Spitsbergen in 1928, and the first flights ever to be made in the Antarctic, including the Graham Land flight of December 20, 1928. The election of Corresponding Members was pending when Eielson was reported missing on a relief expedition to the northeast Siberian coast, a hazardous undertaking. On February 18 his body was found near the mouth of the Anguem River. To his skill, courage, and devotion to duty Sir Hubert has paid high testimony.

VERNOR CLIFFORD FINCH is professor of geography at the University of Wisconsin. His work has lain primarily in economic geography, particularly in relation to agriculture. In collaboration with O. E. Baker he compiled the fundamental "Geography of the World's Agriculture" (1917), in which the "dot" method of showing distributions is used. Recently he has been developing new methods of detail mapping for land utilization studies.

HERBERT JOHN FLEURE is professor of geography in the University of Wales, Aberystwyth, and professor-elect of geography in the University of Manchester. His work in human geography, original and suggestive, has gained much through his allied pursuits in archeology, anthropology, and zoölogy. He is a member of the committee of the International Geographical Union for the study of the rural habitat and of the recently appointed committee of the British Association for the study of early man in East Africa. He is active in the work of the (British) Geographical Association and editor of its magazine *Geography*.

BARON STEN DE GEER is professor of geography at the University of Göteborg. He has brought a fresh viewpoint to his studies in economic and regional geography; and he is especially known for his original work on geographical methods, including graphic representation, the most notable example of which is his atlas of the population distribution of Sweden using the "dot" and "sphere" symbols.

WILLIAM B. MAYO is President of the Detroit Aviation Society, whose outlay in money and time contributed so greatly to the success of the Wilkins Arctic Expeditions of 1926–1928; while the generous attitude of so many of its members was an encouragement to the explorer in his Antarctic expeditions of 1928–1929.

JULIO GARZÓN NIETO is chief of the Oficina de Longitudes of Bogotá, Colombia, established by him many years ago to secure data for the compilation of maps of the various states on a scale of 1:500,000. About one-half the republic is now covered by these state maps, and upward of 2000 astronomical positions have been established, affording a basis for map compilation to be found nowhere else in Hispanic America. Dr. Garzón Nieto conducted the surveys for his government of the Ecuador-Colombia boundary in 1916 and acted on the mixed commission that studied the Venezuela-Colombia boundary in 1901.

HENRI FRANÇOIS PITTIER is Director of the Museo Comercial of Venezuela in Caracas. He was for many years engaged in plant exploration in Central America on behalf of the U. S. Department of Agriculture. Later he made geographical studies and established meteorological stations for the government of Costa Rica, in which capacity he conducted reconnaissance surveys over large areas and in 1912 produced a topographic map of the republic on the scale of 1 : 500,000 that is still the best map of Costa Rica.

HARALD U. SVERDRUP is chief of the section of dynamic meteorology of the Geophysical Institute, Bergen. He was a member of the *Maud* Expedition of 1918–1929, which, under Amundsen, made its way from Norway to Alaska around the Siberian

coast; and he was scientific leader of the *Maud* expedition of 1922–1925, whose prime purpose was to carry out magnetic observations for the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. Important studies of meteorology, tides, and ice conditions on the continental shelf north of Siberia were also made.

ANNUAL REPORT OF THE COUNCIL

New York, January 21, 1930

To the Fellows of the Society:

In pursuance of its main object as a research institution the Society has encouraged and supported field work, has provided facilities for the training of the members of various expeditions, and, by enlarging its research facilities, particularly its research catalogue, has been able to provide for a 50 per cent increase in the number of consultants. Through its quarterly journal it has again placed in the hands of American geographers an unrivaled collection of original material, and at the same time it has continued its publication of monographs and maps based upon original field data. Through the wide distribution of its publications in polar geography and particularly its new map of the Antarctic to 16,000 schools and colleges throughout the United States it has provided authentic material for that wide public interested in current exploration.

The following summary of the activities of the Society during the past year reflects the variety of the work upon which it is engaged.

The Geographical Review

The Society's relation to polar exploration is suggested in a group of three papers on the Antarctic. There is Captain Sir Hubert Wilkins' narrative of his Antarctic flights of the 1928–1929 season with its accompanying map of the discoveries on a scale of 1 : 6,000,000 and a splendid series of aerial photographs. The broad significance of the results is analyzed by the British authority Dr. Hugh Robert Mill of the Scott Polar Research Institute. Major Gunnar Isachsen writes from personal experience in describing "Modern Norwegian Whaling in the Antarctic." We are to have further material from this interesting region through the generosity of Admiral Byrd in promising a part of his scientific results for publication here and in similar assurances from Captain Sir Hubert Wilkins and Sir Douglas Mawson.

Thanks to the work of a member of its own staff, Mr. O. M. Miller, the *Geographical Review* for 1929 opens with an account of "The 1927–1928 Peruvian Expedition of the American Geographical Society." This is accompanied by a topographical survey on a scale of 1 : 200,000 of the region about the sources of the Marañon and the Mantaro, an area of critical importance heretofore unmapped. Joseph H. Sinclair, "In the Land of Cinnamon: A Journey in Eastern Ecuador," follows up his earlier work in that region. "Explorations in Colombia," by F. O. Martin, who spent several years in the Cordillera Oriental and the border llanos south of Bogotá, also resulted in valuable surveys which will be incorporated in the Society's map of Hispanic America. Political geography in South America is represented by William E. Rudolph's discussion of "The New Territorial Divisions of Chile with Special Reference to Chiloé." Our librarian, Dr. J. K. Wright, outlines the Society's plan for the regional study of New England in an article under that title which presents, with illustrations, the preliminary investigations already made. Other studies on the North American continent include a paper on Great Slave Lake by J. Mackintosh Bell, a study in the types of land surface of the Imperial Valley by Stanley W. Cosby, and a description of some interesting population groups by J. W. Hoover in a paper entitled "The Indian Country of Southern Arizona."

Among foreign contributors to whom we are indebted are two distinguished Italian geographers. Giotto Dainelli, of Florence, writes on "The Italian Colonies." Roberto Almagià, of Rome, describes "The Repopulation of the Roman Campagna," the rapidly advancing reclamation of a countryside prosperous in classical times but long fallen into neglect. Miss Ellen Churchill Semple continues her studies of the Mediterranean in classical times with a charming essay on "Ancient Mediterranean Pleasure Gardens." An important reclamation project in Egypt, "The Qattara Power Scheme," is outlined by the Surveyor General, H. Sirry Bey; while Benjamin Semenov-Tian-Shansky describes an experiment under way in Russia, the establishment of a strictly geographical museum.

"Can Japan Develop Industrially?" challenges one of the proposed solutions for the pressing population problem in that country. John E. Orchard answers that question on the basis of his recent investigations in the field. A. T. Strahorn, whose work has been recognized by British officials, describes the "Agriculture and Soils of Palestine" in a paper including a preliminary soil map and a table of soils classification. Interest in the new subject of soil science is also manifested in Mr. L. A. Wolfanger's "Major World Soil Groups and Some of Their Geographic Implications."

Oceanographical work is represented by Mr. H. A. Marmer's study of "The Gulf Stream and Its Problems," while the veteran oceanographer Otto Pettersson contributes "Changes in the Oceanic Circulation and Their Climatic Consequences." Professor Mark Jefferson's paper on "The Geographic Distribution of Inventiveness" has attracted wide attention, as has Dr. Wigmore's "A Map of the World's Law," which shows in color the distribution of the present-day legal systems of the world.

Altogether there were published in the *Geographical Review* for 1929 42 leading articles, 70 items of geographical record, and 63 reviews. In addition to the many text maps there were 6 insert maps.

We are indebted to a Fellow of the Society, Robert Lee Forrest, for the contribution to nearly 250 foreign scholars of copies of the *Geographical Review* for 1929. Every institution that distributes a journal is aware of the difficult conditions under which scholarly work was resumed in Europe after the World War and the great handicap under which professors and graduate students carry on their work. In view of these conditions Mr. Forrest's action is most praiseworthy, and it is hoped that the practice which he initiated may be continued during 1930.

Books and Maps

During the past year the Society completed the publication of the series of six volumes on Arabian geography, history, and folklore by Professor Musil of the Charles University, Prague. The final volume is entitled "The Manners and Customs of the Rwala Bedouins."

In continuation of its policy of earlier years the Society has contributed a part of the annual *Bibliographie Géographique* in collaboration with the Association of French Geographers; and has encouraged the production of Volume 6 of a series now well known to the Fellows of the Society, "Practical Hints to Scientific Travellers," edited by Professor H. A. Brouwer, this latest volume in the series dealing with Canada, Argentina, Oceania, Madagascar, and Tropical West Africa.

Much new source material has been assembled for the Millionth Map of Hispanic America, the new material including the survey of the Cerro Duida region of southeastern Venezuela and sketch maps of Mt. Roraima and vicinity. The work of the Society has been completed on forty-five sheets of the Millionth Map, and its work is well advanced on fifteen additional sheets.

The first of the series of volumes on the Catalogue of Maps of Hispanic America is in page proof, and 1930 will see the appearance of the first of the volumes, an enterprise that has engaged the Society at intervals during the last seven years.

Through its access to original surveys the Society was able to produce a new wall map of the Antarctic in color showing the outline of the Antarctic continent and its relation to South America, Africa, Australia, and New Zealand. The map includes an inset showing the topography of the Antarctic archipelago in detail and a series of ten photographs illustrating the chief topographic discoveries of the Wilkins-Hearst Antarctic Expedition of 1928–1929. Through the generosity of Mr. Hearst this expedition was made possible and the data assembled for the distribution of the Antarctic map to the educational system of the United States on a scale never before attempted by any institution and with results most gratifying to the Society. The hundreds of letters that have been received testify to the extraordinary value of the map and its wide use in following current Antarctic exploration.

In view of the present interest in both the Arctic and the Antarctic the Society has summarized during 1929 the work of expeditions both north and south since the introduction of the airplane into polar exploration in 1925. The results are a physical map of the Arctic, a bathymetric map of the Antarctic, and a booklet of text giving a brief history of recent polar exploration, all of which will be distributed to Fellows of the Society in 1930.

Field Expeditions

We referred in last year's report to the Society's coöperation with Admiral Byrd in his Antarctic expedition. We remained in communication with him during the year, supplying technical information at his request and recommending his second great flight of the season, in which he traversed new coastal territory outside the Ross Dependency and then, flying inland, tied up his discoveries, which include a new mountain range, with hitherto unexplored coast. Admiral Byrd has generously promised to turn over part of his scientific results to the Society for publication in the *Geographical Review*, and the Society has been requested to prepare the final official maps of the expedition as soon as practicable after its return.

Captain Sir Hubert Wilkins has received further endorsement of his plans from the Society and by the use of his equipment of last year was able to undertake an exploration of the western border of the Antarctic archipelago. With the coöperation of the British Antarctic Research Committee and through the use of its ships, the *William Scoresby* and the *Melville*, he was able to leave Deception Island, his base, and advance well toward Alexander I Land. Farther advance was thwarted by the ice when he was about 150 miles due north of Charcot Island. He reports to the Society the definition of Charcot Island and the tracing of 300 miles of new coast line which continues Hearst Land westward beyond the 80th meridian. He has thus outlined about 500 miles of coast from the Weddell Sea westward, in addition to making short flights that have tied in the west coasts of the islands that comprise the Antarctic Archipelago with the east coasts as laid down upon his preliminary maps of last year.

The Society was happy to confer with Sir Douglas Mawson in the organization of his Antarctic expedition and to obtain in the United States substantial support for the work and has been generously offered the first general account of the scientific results. The expedition is primarily oceanographic in character and will concentrate its attention upon the continental shelf in the African quadrant. The expedition went out in Scott's old ship, the *Discovery*, well equipped for modern oceanographical work and carrying a small plane by means of which short exploratory flights will be made inland in order to extend the range of discoveries on the land side.

The School of Surveying

In addition to providing instruction for a limited number of students the School has interested itself in aerial surveying and in providing technical information by personal visit and correspondence. Several new instruments and many new books

have been acquired, and the Shortt Synchronome clock has been completely installed. The compilation of the star lists employed in determining latitude and longitude has been completed, and the lists will shortly be issued in book form.

Studies in Pioneer Settlement

We referred last year in our annual report to the beginning that had been made by the Society in the study of undeveloped lands. The preparation of the first book on the subject has been well advanced. This will include papers by 25 or 30 authors who will speak from first-hand knowledge of the principal pioneer areas in the world today. A strong committee of Canadian scholars has been at work during the past field season upon the so-called Canadian Pioneer Problems Project. This program has had the endorsement of the Social Science Research Council and promises to yield results of great value to scholarship as well as to government administrators. The program of field work for 1930 has been mapped out by the Canadian committee and has been approved by the Social Science Research Council, which has also provided funds through our Society for carrying out the coming season's work on an enlarged scale.

In the meantime the Society has encouraged through small grants and otherwise the wider study of pioneer conditions in pioneer regions of other continents, thus providing for independent field studies of great ultimate value to science and to humanity. The object of these studies is to provide eventually a science of settlement; and, while the first object in view is humane and has to do with the improved conditions of settlement, it should not be overlooked that pure science will gain immeasurably through the bringing together of more accurate information from the borderlands of the world where man is in closer touch with his environment and more greatly influenced by it than anywhere else.

New England Studies

As announced in the report for last year, the Society is conducting a regional study of New England as an initial step in a series of population studies of the United States. The coöperation of between twenty and thirty economists, sociologists, and men of affairs has been secured toward the preparation of a book in which outstanding problems will be discussed from many angles. The Society is also making an investigation of documentary materials and surveys bearing on contemporary issues in New England. The objectives of the Society's project are outlined in a paper entitled "New England" which appeared in the *Geographical Review* for July, 1929.

Representation at Scientific Meetings

The Society sent representatives to the annual meeting of the Division of Geology and Geography, National Research Council, on April 27 and to the annual meeting of the Association of American Geographers at Ohio State University, Columbus, Ohio, on December 30 and 31 and January 1.

The Director of the Society, by appointment of the Council on Foreign Relations, attended the London Conference of Institutions for the Scientific Study of International Affairs on March 11–14, 1929.

Library

Additions to the library during the year comprise 825 books, 617 pamphlets, 9504 new issues of periodicals, 4439 maps, and 71 atlases. The maps include a notable collection of 2000 sheets of the Japanese Land Survey of Japan, Korea, and Sakhalin.

The library has continued its activity in accordance with the principles explained in the report for 1926. Cards representing over 6000 volumes, periodical articles, pamphlets, and maps were entered in the special research catalogue.

The library also coöperated in the publication of the current supplement to the *Union List of Serials* and the *List of Serial Publications of Foreign Governments*. A list of geographers in the universities of the United States was completed, and a special file organized for material on geographical aspects of aviation.

Gifts and Notable Accessions

It gives the Council great pleasure to acknowledge in its annual report and by special resolution of the Council the gift to the Society by Miss Cora Griffin and Mrs. Herbert R. Woods of two log books of the U. S. Brig *Rescue*, commanded by Samuel Palmer Griffin, their father, during her voyage to the Arctic regions, 1850 and 1851, in search of Sir John Franklin.

Sets of photographs have also been received from the following named Fellows of the Society: Miss Mary S. Johnston of Surrey, England; Mr. Henry J. Thayer of Boston, Mass.; and Mrs. Givenwilson Kilner of Manila, P. I. Acknowledgment is also made of a collection of lantern slides on meteorological subjects from Dr. Guy Hinsdale of White Sulphur, W. Va.

The Society is greatly indebted to its President, Dr. John H. Finley, for his thoughtfulness in preparing over a period of years a globe which he has now presented to the Society. It bears the signatures of most of the fliers who have attempted notable flights as well as the courses laid down by themselves upon the globe. The whole forms an invaluable record of that first part of the earth that was thought conquerable by airplane and airship. As an original record the globe takes rank with the great cartographic masterpieces of earlier times, and its value will increase in successive generations.

Honors

At the head of the list of honors for 1929 stands Rear Admiral Richard E. Byrd, who was awarded the David Livingstone Centenary Medal in recognition of his brilliant work in the Antarctic and the contributions which his observations will make not only to the map of the Antarctic but to an understanding of the origin of the features of the Ross Sea area.

For several years the Cullum Geographical Medal has not been awarded, in order that accumulated funds would make it possible to award it to distinguished persons of different nationality in a given year. The Council has selected the following scientists for special recognition through the award of this gold medal for 1929: Hugh Robert Mill, Scott Polar Research Institute, Cambridge, England; Jean Brunhes, Collège de France, Paris; Alfred Hettner, Ruprecht-Karls-Universität, Heidelberg, Germany; Jules de Schokalsky, Russian Geographical Society, Leningrad.

The Charles P. Daly Gold Medal for 1929 was awarded to Cav. Filippo de Filippi of Florence, Italy, and to Émile Félix Gautier, University of Algiers, Algeria.

Three Honorary Members were elected in 1929: Alfredo Jahn of Caracas, Venezuela; Sir Napier Shaw, former head of the British Meteorological Office; and Hussein Sirry Bey, Surveyor-General of Egypt.

The following have been elected to honorary Corresponding Membership: Julio Garzón Nieto, Director Office of Longitudes, Bogotá, Colombia; Henri Pittier, Museo Commercial, Caracas, Venezuela; Roberto Almagià, Royal University, Rome; Harald U. Sverdrup, Geophysical Institute, Bergen; Lieut. Ben Eielson; Herbert John Fleure, University College of Wales, Aberystwyth; Henry B. Bigelow, Museum of Comparative Zoölogy, Cambridge, Mass.; Sten De Geer, University of Göteborg; Vernor Clifford Finch, University of Wisconsin, Madison; William B. Mayo, Detroit Aviation Society, Detroit.

Lecture Program

The speakers and titles upon the Society's lecture program during the past year are as follows: Mr. Joseph H. Sinclair and Mr. O. M. Miller on their expeditions in Eastern Ecuador and Peru; Mr. Owen Lattimore, "The Desert Road to Turkestan"; Mr. Lowell Thomas, "Through Romantic India and into Forbidden Afghanistan"; Captain Sir Hubert Wilkins, "Antarctic Exploration by Airplane"; Dr. Harlow Shapley, "The Third Dimension of Geography"; Dr. Alfred V. Kidder, "An Air Reconnaissance of the Maya Country."

Fellows

The number of Fellows at the close of the year was 5807, of whom 393 are Life Fellows. In addition there were 5 Honorary Members and 43 Corresponding Members.

Report of the Treasurer for 1929

The Council has received a report from the Treasurer giving a summary of the income and expenses of the Society, and the accounts of the Society have been audited by certified accountants whose report is on file at the office of the Society.

Philip W. Henry, *Chairman*

REPORT OF THE SPECIAL COMMITTEE

New York, January 16, 1929

The committee appointed at the meeting of the Council held on December 19, 1929, to nominate officers for the vacancies to occur in the Council in January, 1930, beg to nominate the following named gentlemen for the offices designated and move that the same be approved and presented to the Society for election at its meeting to be held on January 21, 1930.

		Terms to expire in
President	John H. Finley	January, 1931
Vice-President	A. Hamilton Rice	January, 1933
Foreign Cor. Secretary	Frederic C. Walcott	January, 1933
Treasurer	Henry Parish	January, 1931
Councilors	Frederick Hellmann Oliver B. James H. Stuart Hotchkiss Frank L. Polk	January, 1933

Philip A. Carroll
Hamilton Fish Kean
Roland L. Redmond
Committee

GEOGRAPHICAL RECORD

NORTH AMERICA

Cotton Manufacturing in the South and in New England. The Piedmont of the Southeastern States has of late years taken the place of New England as the principal cotton manufacturing section of the United States. From small beginnings about 1880 the industry in the South has seen a phenomenal growth. The U. S. Census of Manufactures for 1899 counted only 4,089,000 active spindles in the Southeast as against 13,166,000 in New England. By 1925 the figure for the Southeast had risen to 16,597,000, as contrasted with 15,976,000 for New England. The industry in New England, moreover, has declined since 1919, when there were 17,843,000 active spindles in that section.

Will the South maintain its recently acquired supremacy? Is the decline in New England permanent or temporary? Into the discussion of these questions the element of propaganda has entered, often obscuring or distorting the fundamental geographical and economic facts. There is particular value, therefore, in two recent estimates of the situation by European scholars, whose point of view is presumably detached and objective.

In the *Annales de Géographie* for July, 1929, there appeared a paper by the late D. Pasquet entitled "L'industrie du coton dans le Sud-Est des États-Unis." The writer was well versed in the economic history of the United States and had acquired first-hand knowledge of cotton manufacturing during an extended tour of field work through New England and the South in 1925–1926. A more detailed economic study, in which the costs of production in both sections are analyzed and compared, was contributed by Andreas Predöhl to *Weltwirtschaftliches Archiv* for January, 1929, "Die Südwanderung der amerikanischen Baumwollindustrie."

Pasquet and Predöhl show that, although the southern mills are nearer the cotton fields than those of New England, this fact is relatively unimportant. Indeed the southern manufacturers are obliged to import by rail considerable quantities of raw cotton from Texas and Oklahoma at a cost almost equal to that of shipments by water to New England. Likewise the advantages which the South enjoys through possibly superior power facilities are of no great significance, since the expenditure for power is but a small fraction of the total cost of manufacture. Despite misconceptions to the contrary, child labor in the southern mills is no longer allowed and hence offers no advantage to the southern mill owner. Sometimes it has been said that the mill hand of the Piedmont, sprung from old American stock, is an individualist and therefore less embued with class feeling and less subject to the disturbing influence of agitators than the foreign operative of New England. Pasquet, however, observes—prophetically, in the light of the recent troubles at Gastonia and Marion—that nothing guarantees that this American individualism and the absence of class feeling will be maintained. Nor are the differences in climate between New England and the Piedmont sufficient to lend any marked superiority to either region. There was a time when the high relative humidity in New England was a decisive factor in the production of quality goods, but the invention of mechanical humidifiers has done away with any advantage arising from this circumstance. There is no scientific evidence to show that either more or less efficient work can be done in the climate of the Piedmont than in that of New England, propaganda to the contrary notwithstanding.

Cheap labor, longer working hours, and to some extent favorable financial legislation and a public opinion that has, possibly, been more hospitable to the manufactur-

ing interests than in New England are, in Pasquet's opinion, the fundamental reasons why the South has taken the lead. Predöhl's analysis brings him to similar conclusions. He estimates that the differential in the cost of manufacture in favor of the South amounts to about $6 per year per spindle or, roughly, to 14 per cent of the total cost per year per spindle in the north. Of this $6, some $4 represents the difference in labor costs.

In *Economic Geography* for January, 1928, Robert M. Brown writes that "a faith in a day when there shall be an equalization of conditions between the northern and southern cotton manufacturing districts appears strong among some of the northern textile men. Others apparently not so sanguine are striving with supreme efforts to overcome the handicap placed upon them by the southern labor status." At the present time conditions are certainly not trending toward equalization. Predöhl points out that the "total difference in cost of manufacture between North and South is growing greater rather than less and has been progressively increasing even in the manufacture of quality goods." Equalization will be postponed as long as the southern manufacturer can pay less for more work than his northern competitor. That he can continue to do so for a long time to come is probable. The farming and mountaineer population of the Piedmont and southern Appalachians is a vast reservoir of potential labor. It will be a long while before this reservoir is exhausted and a long while before the industrialization of the South brings about, through competition for labor, a general rise of wages to northern levels.

A Regional Plan of New York City and Its Environs. Congestion of population is a tradition in New York. On the long and narrow island of Manhattan expansion was possible only in a northerly direction, and a slight increase in area was accompanied by disproportionately long distances from the center of the city. For miles beyond the limits of urban development high, speculative land values prevailed and further retarded expansion. By 1820 the wards south of Canal Street were overcrowded, and by the middle of the century congestion at the south end of Manhattan was greater than that in the worst parishes of London today. The present population of New York is 6,000,000, and that of the New York Region is 10,000,000. It is estimated that the Region will support a population of 21,000,000 by 1965. In 1917 Sidney A. Reeve pointed out that extension of rapid transit lines served only to increase the potential area of congestion (Congestion of Cities, *Geogr. Rev.*, Vol. 3, 1917, pp. 278–293). Today each mile of rapid transit extended into undeveloped regions makes possible the housing of 25,000 additional families in apartment buildings or 4500 in detached houses. Fingers of high-priced land and dense population radiate from the city and parallel the rapid transit lines and through highways. In the less accessible areas between, land values are lower and the population less congested. By utilizing such areas more efficiently the New York Region, containing 5528 square miles, could support three times the estimated population for 1965 without greater congestion than today.

At present there is an outward trend of population, a reaction to the congestion of the city. Between 1905 and 1925 the percentage of the population living within four miles of the city hall has decreased from 50 to 30 per cent. In the southern part of the island the actual number of residents is decreasing. Conversely, the population of the outlying boroughs of New York is increasing more rapidly than that of Manhattan, and the population of Westchester County and parts of New Jersey is increasing at a greater rate than that of any of the boroughs of New York. A corresponding outward movement of industry began about 1900 with the decline of wood manufacturing on Manhattan. This was followed by a decline in the metal, textile, food, chemical, and clothing industries. Since 1900 manufacturing has increased three times as rapidly in the outlying sections of the region as on Manhattan. Newark has become the lumber center of the region, oil refineries flank both

sides of Kill van Kull, and sugar mills and copper refineries have been relegated to the New Jersey shores. Sixty-one miles of undeveloped water front located on Long Island, in New Jersey, and along Arthur Kill are still available for industries requiring port facilities combined with an extensive area. But without adequate

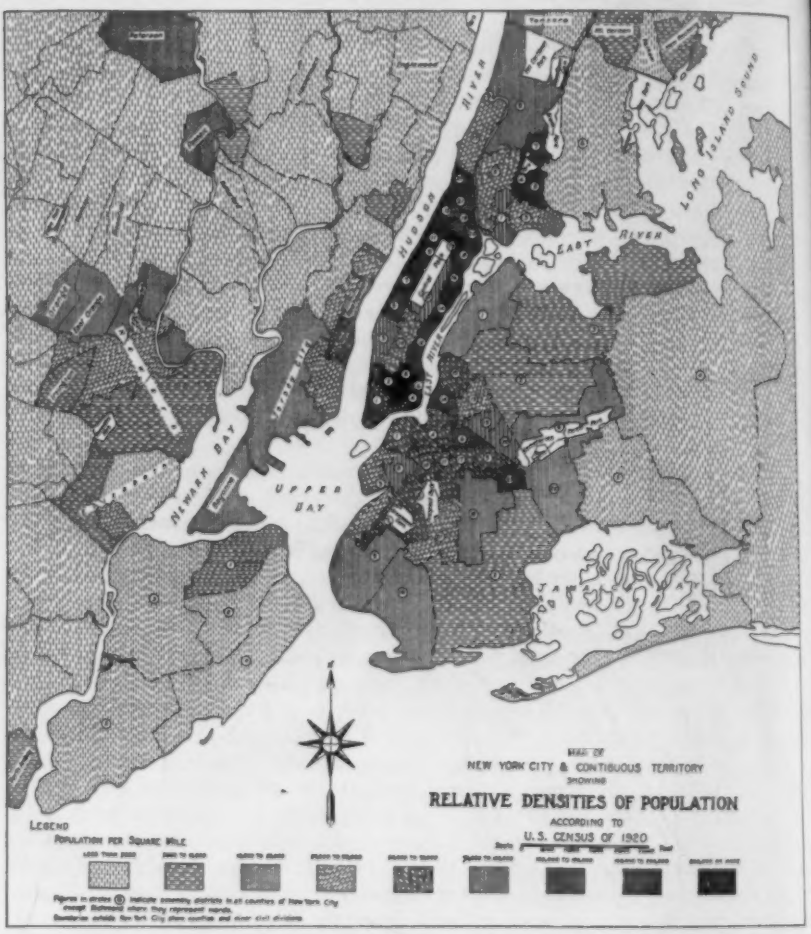

FIG. 1—Population density in New York City and contiguous area in 1920. Reproduced on a reduced scale from Figure 19, Volume 2, of the Regional Survey.

transportation the outward trend may merely result in the establishment of new centers of congestion.

Throughout the New York Region the main routes of transportation focus on Manhattan, and adequate connecting lines are lacking. Outlying industrial districts must depend upon the local labor supply, and suburban residents are limited to local employment or to business near the commuting terminals on Manhattan. This increases the congestion of working population near the railroad terminals and increases the land values. It encourages the construction of skyscrapers whose population further increases the congestion.

The present lack of communication between outlying communities is largely a result of topography. The Hudson River separates New Jersey from New York City

and Westchester, Kill van Kull and Arthur Kill complete the isolation of Staten Island, and the East River and Long Island Sound separate Long Island from the other parts of New York City and Westchester. In Westchester County the alternation of longitudinal ridges and valleys makes the construction of east-west railroads

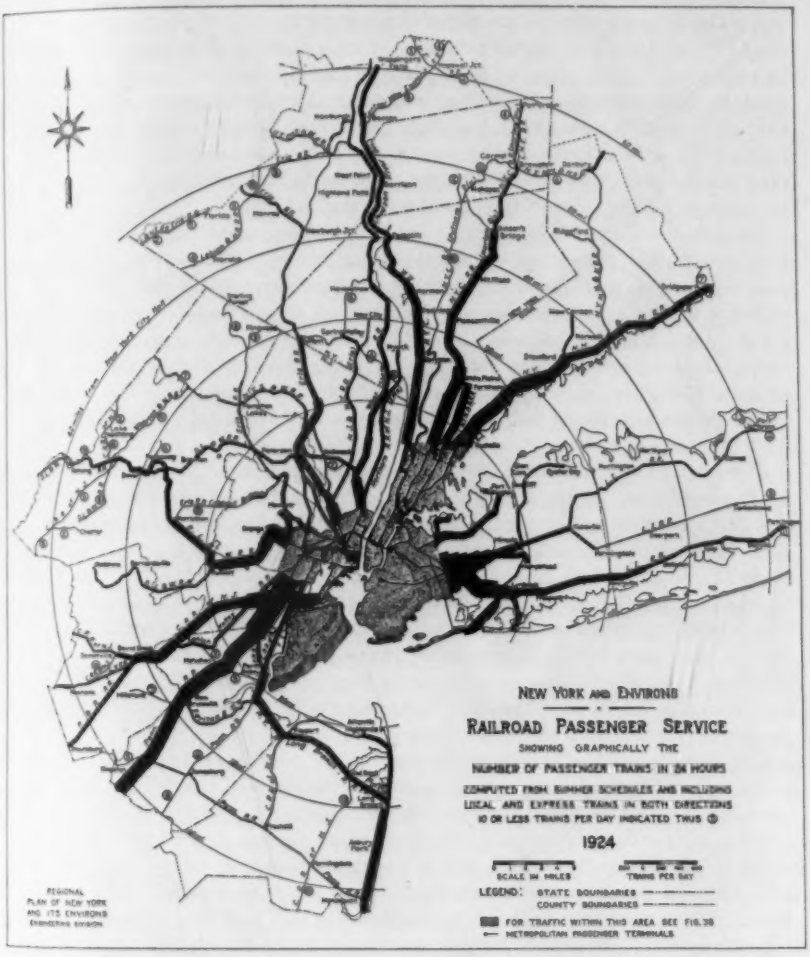
NEW YORK AND ENVIRONS
RAILROAD PASSENGER SERVICE
SHOWING GRAPHICALLY THE
NUMBER OF PASSENGER TRAINS IN 24 HOURS
COMPUTED FROM SUMMER SCHEDULES AND INCLUDING
LOCAL AND EXPRESS TRAINS IN BOTH DIRECTIONS
10 OR LESS TRAINS PER DAY INDICATED THUS ⑩
1924
SCALE IN MILES
TRAINS PER DAY
LEGEND: STATE BOUNDARIES
COUNTY BOUNDARIES
FOR TRAFFIC WITHIN THIS AREA SEE FIG. 38
METROPOLITAN PASSENGER TERMINALS
REGIONAL PLAN OF NEW YORK AND ITS ENVIRONS

FIG. 2—An illustration of New York City's traffic problems. Reproduced in a reduced scale from Figure 37, Volume 4, of the Regional Survey.

and highways both difficult and expensive. The Newark Bay salt marshes and the Hackensack meadows separate the New Jersey communities along the Hudson from those farther inland.

The same barriers have also contributed to the political complexity of the region, which includes parts of three states and 436 local governments. Lack of unity has prevented the development of a regional plan by any governmental agency. For this reason it was undertaken by the Russell Sage Foundation. An intensive survey of the physical and economic aspects of the region, extending over a period of six years, preceded the formulation of the regional plan. The results of the survey are contained in eight volumes: (1, 1A, 1B) Major Economic Factors in Metropolitan

Growth and Arrangement (1927, 1928); (2) Population, Land Values and Government (1929); (3) Highway Traffic (1927); (4) Transit and Transportation (1928); (5) Public Recreation (1928); (6) Buildings, Their Uses and Spaces about Them (to be published during 1930); (7) Neighborhood and Community Planning (1929); (8) Physical Conditions and Public Services (1929). Among the maps of especial interest contained in these volumes are those showing the density of population in the New York Region from 1850 to the present and the estimated distribution of population in 1965 (Vol. 2), the value of land per acre and per foot of frontage (Vol. 2), the quantity and distribution of highway and railroad traffic within the region today and that estimated for 1965 (Vols. 3 and 4), the flow of freight entering and leaving the region (Vol. 4), the present utilization of the water front (Vol. 5), the ownership of land under water (Vol. 5), and the type of ownership of water supply systems within the region and the areas of their catchment basins (Vol. 8).

In Volume 1 of the Regional Plan (The Graphic Regional Plan: Atlas and Description, 1929) both present and suggested land utilization and means of communication are presented in map form, on the scale of approximately an inch to a mile, and accompanied by a comprehensive explanation. A second volume will suggest details for the application of the plan. The plan is flexible enough to permit modification and general enough to allow local option in the development of the details. Its essential feature is the distribution of industry, business, and population, based upon improved transportation and maintained by a well balanced arrangement of land uses.

The same principle underlies the suggested reorganization of the trunk lines entering the region, the commutation system, and the highways. An outer belt line will enable passengers and freight destined for outlying sections to by-pass the city. Inner belts and loops will facilitate intersuburban communication. The commutation system is based upon an inner loop connecting the railroads of Manhattan with those terminating in New Jersey, and an outer belt supplying direct communication between outlying communities. A corresponding highway system includes a metropolitan loop, inner belt lines, express highways, and parkways reserved for passenger vehicles. The application of these plans requires the construction of bridges or tunnels across the Hudson, the East River, and the Narrows. These will help destroy the restricting influence of Manhattan's insular location.

It is essential that planning should precede the development of new communities to predetermine the location of business and industry in relation to residence, to provide for transportation, and to reserve adequate space for parks, recreation grounds, and public institutions. For regions at present overcrowded the creation of parks on islands of the East River, the development of parts of the waterfront for recreation purposes, and provision for easy access to regional parks offer some relief. The opening of new traffic ways will create new land values requiring a higher type of development and stimulate the movement of population to the new and comparatively inexpensive suburban areas.

The essential features of both the Regional Survey and Plan have been condensed in a single volume, "Mastering a Metropolis," by R. L. Duffus (Harper and Brothers, New York, 1930). Technical details have been omitted, and the resulting account is both interesting and readable.

A City Plan for Vancouver, Canada's Gateway to the Orient. Vancouver has established its position as the premier grain port of the Pacific coast of North America, exporting in 1928 over 97,000,000 bushels. Before the war Vancouver was but the distributing point for British Columbia and the outlet for an insignificant volume of transpacific trade, whose most important item was lumber and wood products. In 1918 Vancouver made her first shipment of wheat, eight bushels, to Japan. A year later experimental shipments of grain left Vancouver for Europe via the Panama

Canal. By 1928 the export of wheat to Japan had increased to over 9,000,000 bushels, export to China amounted to 3,000,000 bushels, and 66,000,000 bushels were shipped to Europe. Wheat is the most important item in Canada's growing trade with the Orient. Between 1913 and 1928 the value of Canadian exports to Japan increased from $1,000,000 to $33,0000,000, and that of exports to China from $700,000 to $13,000,000. Next to the United Kingdom and the United States, Japan is the largest purchaser of Canadian produce. In recognition of this remarkable development Canada has appointed an Envoy Extraordinary and Minister Plenipotentiary to Japan, whose chief duty is the arrangement for trade between the two countries. A similar representative of ambassadorial rank will be appointed from Japan to Canada.

Paralleling the growing market is a constantly increasing production of wheat in the Prairie Provinces, due in part to the extension of railroads and the opening up of new farm lands and in part to increased production per acre. The greatest increase in wheat acreage and yield has occurred in Alberta, the province nearest to and tributary to Vancouver (Report on the Grain Trade of Canada for the Crop Year Ended July 31 and to the Close of Navigation 1928, Ottawa, 1929, pp. 38–41). The completion during 1928 of the 2,500,000-bushel elevator of the Alberta Wheat Pool indicates a continued westward movement of wheat.

Since 1915 the population of Vancouver has increased from 100,000 to 325,000. Her market is increasing; and the hinterland still possesses rich undeveloped agricultural, forest, mineral, and water power resources. Two transcontinental railroads terminate in Vancouver; and the harbor—containing 48 square miles, 28 of which are landlocked—is extensive enough to accommodate a substantial increase in trade and industry. Consequently the estimate of a population of 500,000 by 1940 and 1,000,000 by 1960 does not seem oversanguine.

In 1926 a Town Planning Commission was appointed to outline the future development of Vancouver. A firm of city-planning and landscape engineers was engaged to survey the highway pattern, the transit situation, railroad and harbor facilities, zoning, civic art, and public recreation (A Plan for the City of Vancouver, British Columbia, Including a General Plan of the Region, 1928, Vancouver, 1929). The city is one of single-family homes, and it is the ambition of the planners to preserve this character. "Except for bridge approaches, there is no real traffic problem in the business district. . . . Few large cities can show so little traffic congestion as Vancouver: a condition that can only be maintained by careful city planning." The plan is largely preventive, involving no radical changes in existing conditions. Detailed maps illustrate the suggested changes in existing conditions and plans for future development. These have been divided into two groups, the projects that should be completed by 1940 and those of less immediate importance to be completed by 1960. But the greatest single asset of Vancouver is her harbor, the link connecting Canada with the Orient. Like other Canadian ports, Vancouver is controlled by a "Harbour Commission," a completely self-supporting organization appointed by and representing the Dominion Government, in consequence of which special problems arise involving the city, provincial, and national governments.

Motor Transportation in Pennsylvania. A survey of the fruit and vegetable supply of fifteen cities in Pennsylvania revealed the fact that in all but four there was a drop in the carload lots of produce received by rail in 1927 (*Pennsylvania Dept. of Agric. Bull. No. 461* (Vol. 11, No. 7) 1928). This decrease is attributed not to a diminished quantity of material supplied the towns but to the fact that the motor truck is being used more and more for the transportation of supplies. Of the fifteen cities only Wilkes-Barre and Scranton, both in the heart of the mountainous anthracite coal region, were able to report a noteworthy increase in their rail shipments. At the same time motor trucks are an important element of transportation in the hard

coal fields. This is shown by two maps accompanying a report on transportation on the state highways of Pennsylvania (Report of a Survey of Transportation on the State Highways of Pennsylvania by the U. S. Bur. of Public Roads and the Pennsylvania Dept. of Highways, 1928). The two large maps [1:380,000] accompanying the report show traffic in relation to the density and distribution of population and the distribution of natural resources.

From a rough division of the state on the basis of total motor vehicle traffic, motor truck traffic, the composition of truck traffic, population density, and population trends, three major geographical sections are derived. (1) The Eastern Section includes eighteen counties, each of which had a population density of more than 100 persons per square mile in 1920. In 1920 this region contained a little over half of the population of the state, concentrated on rather more than one-fifth the area. It contained over 44 per cent of the total vehicle mileage of the state highway system with but 27 per cent of the state highway mileage. (2) The Western Section includes twenty counties, fifteen of which had a population density of more than 90 persons per square mile in 1920. One-third of the area of the state is within this section; about one-third of the vehicle mileage; and a little less than one-third of the state highway mileage. (3) The remaining Northern and Central Section, numbering twenty-nine counties, the majority of which show a low density of population, contains only one-tenth of the population of the state and has but 22 per cent of the vehicle mileage of the state, although having 40 per cent of the state highway mileage.

Practically all routes carrying heavy traffic are adjacent to or connect large cities. One-sixth of the total traffic of the state highway system is concentrated in an area about equal to a semicircle around Philadelphia with a radius of thirty-six miles. Motor trucking is employed chiefly for short haul, and indeed 97 per cent is for a distance of less than 100 miles and 67 per cent for a distance of less than twenty miles. Philadelphia is the main trucking area of the state, followed by Pittsburgh and the Wilkes-Barre–Scranton district. Naturally the commodities transported vary greatly with the type of industries in the region. Taking the state as a whole, products of manufacturing constitute the greater part of the tonnage (60 per cent); products of the mines are second (13 per cent). Agricultural products which have an average haul of but twenty or thirty miles are one of the most important individual commodity movements on nearly every highway. In a commercial survey of the Philadelphia marketing area made some few years ago the importance of trucks as a means of distribution of products in this area is emphasized (J. F. Dewhurst: Commercial Survey of the Philadelphia Marketing Area, *Bur. of Foreign and Domestic Commerce, Domestic Commerce Ser., No. 1*, Washington, 1925).

County Areas within the United States. Any quantitative distributional study requires a knowledge of the exact extent of the area involved. In the United States, counties are the smallest political units for which tables of areas are available. At present there are several sets of these tables, all official and all different. A recent revision of county figures reduced the area of Kentucky by about 700,000 acres, of Minnesota by more than a million acres—two per cent of the total area. Because of the imminence of the 1930 census and the subsequent tabulation of statistics the determination of exact area figures becomes especially important. There are a number of difficulties in the way of arriving at accurate determinations of small areas. Tables exist for areal measures on small-scale maps; but figures for smaller quadrilaterals are needed in order to check county areas. The smallest quadrilaterals on the U. S. Geological Survey sheets are of five-minute intervals. With tables of five-minute intervals the area of a county could be calculated directly and the use of the planimeter confined to odd spots only. Areal figures obtained in this manner should be final. Over much of the United States mapping by the Geological Survey

has progressed sufficiently far—nine states have been completely mapped—as to make possible the employment of this method. Such tables are presented in "The Need of Revision of Areal Figures of the United States by Counties," by F. J. Marschner (U. S. Dept. of Agric., Bur. of Agric. Economics, Washington, 1929).

Agriculture in British Honduras. Mahogany today accounts for 72 per cent of the value of exports from British Honduras. Exploitation of this valuable wood has continued over a long period of time. A map of 1789 shows the mahogany forests in the region of the Belize River as being exhausted. In 1883 the mahogany exports were valued at $250,000, while by 1927 their value had increased tenfold. The recent introduction of tractors has made it possible to haul logs from a distance of twelve miles to the streams which form the sole means of transportation. But the use of mechanical transport has also increased production; and, since little effort has been made to propagate this slow-growing tree, it is small wonder that the end of mahogany exploitation is within view.

The development of other natural resources, therefore, becomes imperative. Because of its soil, climate, sparse population, and heavy forest cover the whole economy of British Honduras has hitherto been based on forest products (L. H. Ower: Features of British Honduras, *Geogr. Journ.*, Vol. 70, 1927, pp. 372–386). No mineral deposits of any significance have been discovered. The southern parts of the Colony dominated by the Cockscomb Mountains, the mangrove swamps along the coast, and the "pine ridges" of the flat limestone plains that characterize the north are all unsuitable for agriculture (J. N. Oliphant and Duncan Stevenson: An Expedition to the Cockscomb Mountains, British Honduras, in March, 1928, *Geogr. Journ.*, Vol. 73, 1929, pp. 123–137). Indeed H. C. Sampson, whose "Report on Development of Agriculture in British Honduras" has just been published by the Empire Marketing Board, finds but two types of soil suitable for agriculture—the "cohune ridges" (not elevations but areas of fertile soil characterized by the cohune palm) and the alluvial lands especially along the upper river valleys. This potential agricultural land is scattered and isolated. At present agriculture can hardly be said to exist in the Colony. There are a few sugar cane, coconut, and banana plantations, none of which can be called really successful, especially since the banana plantations in the Stann Creek region have been attacked by the "Panama disease." In the interior away from the rivers the only agriculture is carried on by Indians. This reaches its highest state about San Antonio (Geoffrey Laws: The Survey of the Lubaantun District in British Honduras, *Geogr. Journ.*, Vol. 71, 1928, pp. 224–239). Here the *milpa* system is practiced—the soil is never cultivated, the forest growth quickly returns, and the land is rested for several years before being recleared. Native farming along the rivers makes use of the natural levees, maize being grown on the higher part and rice on the inland slope.

Sampson feels that a successful agriculture based on small, independent farming is possible. Coffee and cacao are suggested as being eminently suitable to the local climate and labor conditions. The country would seem to have real possibilities as a fruit region. Grapefruit is at present being successfully raised on a small scale, and oranges appeared on the export list in 1928. With the establishment of an agricultural station it is to be hoped that local market gardening and dairying may be encouraged to the point of making the Colony self-sufficient instead of completely dependent upon imports.

EUROPE

Overpopulation in the Scottish Highlands. "In Camuslongart, a township of ten or twelve houses, no child has been born for thirty-eight years." The case of this crofting village of the western Highlands is cited by Ian D. Duff in a discussion of the population decline that is the most striking feature of "The Human Geography of

South-western Ross-shire" (*Scottish Geogr. Mag.*, Vol. 45, 1929, pp. 277–295). Decline has been in progress for a century. It began with the introduction of sheep farming on a large scale, encouraged by the excellence of the grazing and the high prices of wool. This alien development from the outside world closed a "golden age" in which the population, anciently rooted in the soil and practically self-supporting, derived prosperity from the produce of their famous black cattle. Farmers evicted from the interior pastures sought refuge in the coastal districts already fully occupied in relation to capacity. Migratory occupations—harvesting in the Lothians, fishing, road making, and the like—offered temporary support, but by the forties a reluctant emigration from the congested districts had set in on a large scale.

The story in southwestern Ross-shire is repeated throughout the western Highlands and Islands. It is a marginal land. "Human settlements in the Highlands are conspicuous for their compactness, small size, peripheral distribution and sparsity," says Alexander Stevens in his recent contribution "The Highlands and Hebrides" ("Great Britain: Essays in Regional Geography," 1928). "The agrarian system to which these settlements belong is known as the crofting system. Fundamentally it is an independent self-contained system, in which the holding provides completely for the wants of the occupants, food, fire, and wearing apparel. As such it is the necessary mode of life of remotely segregated communities, and universal among such. It entails a relatively low standard of comfort in a commercial world, and with the natural growth of population the saturation point of the land is sooner or later passed, to the further depression of the standard of living. The only cure for such overpopulated areas is clearance of one kind or another, a cure which invariably is extremely unpalatable." The prime difficulty that besets attempts to relieve the congested areas is fervently expressed in the recent "Report of the Committee on Land Settlement in Scotland" (Cmd. 3110, Edinburgh, 1928): "The problem in the Highlands involves historical, racial, economic, and social considerations entirely different from those in other parts of Great Britain. We are dealing with a community which has never been industrialized, and resists any attempt at industrialization. Land is the basis of its existence and determines the form of its social life. It has refused to acquiesce in any of the attempts to change the method of holding or using land which have been made in the last 150 years, and the legislature has been compelled to meet the claims it has made to be allowed to live its life in its own way. The Highlander not only insists on living in the Highlands, but insists on living in his own strath or on his own island. What seems an obvious fact to an observer accustomed to other modes of life, that there is not sufficient land to provide for the population in an island or a strath, is not accepted as a fact by the Highlander. He insists on being given land in his own district, and would rather have a hopeless patch of his own native heath than a fair holding in a strange glen. The result is that there are, in the Islands and on the West Coast, congested communities on the fringes of sheep farms, living under conditions of extreme penury, but refusing to leave their homes."

Yet emigration remains the desperate remedy. During the war the large emigration from Scotland—averaging 60,000 a year—was suspended. Subsequently it has been renewed, and it is interesting to note the spontaneity of the revival in its old foyer of the Highlands and Islands. The efforts of the Overseas Settlement Committee at an organized, rationalized emigration have met with indifferent response. "Never," comments Étienne Dennery in analyzing post-war emigration from Scotland, "has the contrast between the plans of a rational emigration and the realities of a spontaneous emigration been so clearly manifested as in this post-war Scotland" (L'Émigration écossaise depuis la guerre, *Ann. de Géogr.*, Vol. 35, 1926, pp. 126–134).

Is it possible to check the decline of population in Highland Scotland? Mr. Duff describes the introduction of a new factor in southwestern Ross-shire—afforestation. It is too early to see results as yet; but present progress of the work is affording some employment, and possibilities of the establishment of pulp mills and of wood-working

industries are suggested. The topography and rainfall that handicap agriculture create ideal conditions for the production of hydro-electric power. By this means industrialization may enter the Highlands and transform life there as it has done in other mountainous regions.

Probably much of the surface of Scotland up to a height of 2000 feet was primitively clothed with forest. Today, according to the census taken in 1924 by the Forestry Commission of Great Britain whose report was issued in 1928, the proportion of the country under woodland is 5.6 per cent. A map accompanying this report shows the least percentage of woodland—under 4 per cent—in the northern Highlands. Successful schemes of afforestation must be related to study of soil conditions, a subject that is gaining increasing attention. Among recent contributions may be mentioned papers by W. G. Ogg: Scottish Soils in Relation to Climate and Vegetation (*Proc. and Papers 1st Internatl. Congr. of Soil Sci.*, Washington, 1928, Vol. 1, pp. 301–309) and by Jethro Otto Veatch: Geography of the Soils of Scotland (*Papers Michigan Acad. of Sci., Arts and Letters*, Vol. 10, 1928, pp. 179–189). The latter classifies the soils of Scotland into three major subdivisions and shows their distribution on a map. The Lowthian soils, comprising less than a quarter of the area and occurring mostly below 900 feet elevation, have at least three-quarters of the cultivated land and the rural population. The Ben Nevis soils, chiefly at heights over 2500 feet, give rise to neither agriculture nor permanent settlement. The Grampian soils, occupying more than half the area, support "mostly grazing of sheep, a small amount of cultivated land, large estates and game preserves, a meager rural population, poverty, and a bitter struggle for the necessities of a bare existence for the tenants and the landless."

A perspective on settlement in the Highlands in relation to Scotland as a whole may be gained from Grace Meiklejohn's "The Settlements and Roads of Scotland" (1927), pleasantly written and illustrated and containing among its intimate touches descriptions of that distinctive feature of the Highlands, the crofting villages.

A Recent Geographical Study of the Vicinity of Fiume. One outcome of the definitive annexation of Fiume to Italy in 1924 has been the publication by the Società di Studi Fiumani of an important geographical monograph on the Carnaro, or province to which the city now belongs. In this volume Guido Depoli treats in conventional order questions of physiography, climate, vegetation, and human geography and appends extensive, bibliographical references to each chapter ("La provincia del Carnaro: Saggio geografico," Fiume, 1928).

The Carnaro forms the Italian half of a well defined natural region, Liburnia, which surrounds the inner extremity of the Quarnero channel, from which the name Carnaro is derived. Dry, bleak, and desolate limestone mountains and karstic plateaus—this is the original Karst (Carso)—enclose rich lowlands eroded on sandstones, where there are "woods and meadows, fields and orchards, and the murmur of water." Along the shores of the Quarnero climate and vegetation are typically Mediterranean: grapes, olives, and even figs are grown, and closely built villages cluster on the water's edge. A short distance back in the upland, however, the climate is more like that of central Europe: snow lies late on the mountains; cereals and potatoes are cultivated in the sandstone lowlands.

The most unusual features of Liburnia from the point of view of physical geography are the karst, the bora, and the tides of the Quarnero. As in all karstic regions the subterranean drainage is more important than the run-off from the surface. Full fledged rivers mysteriously gush forth from cavern mouths. Such is the origin of the Rečina, or stream marking the international frontier between Fiume and the Yugoslav port of Sušak.

The bora blows when a "low" over the Adriatic or Mediterranean causes a draft of cold air to sweep "like a cascade" down the Dinaric mountain sides. "Its vehemence is at a maximum in the gaps, where the air is compressed and condensed.

The unexpected and capricious gusts (*refoli*) are particularly dangerous to navigation, but even on land they can easily upset a loaded railway car. Consequently the railways leaving Fiume are protected at the most exposed points by palisades and thick high walls."

In the Quarnero there is only one tide a day. This has a mean range of 50–70 centimeters and instead of following the moon's cycle is retarded only about two hours in the course of an entire month.

Depoli writes that in the early Middle Ages "our region, nominally subject to Byzantium, found itself exactly on the line of contact between two great historic factors, the Orient and the Occident." This line is but one of many that scholars have sought to draw between those vague territorial concepts, East and West. The fact remains, however, that Liburnia has for centuries lain athwart one of the main racial, linguistic, and cultural frontiers of Europe. Here Slavic Croat met Teutonic Frank in medieval times; here at the present day peasant and pastoral population are almost exclusively Slav, the coastal villages and city of Fiume almost wholly Italian; here during the last decade the establishment of the boundary between Italy and Yugoslavia has led to the verge of war."

Before 1918 Fiume was the seaport of Hungary. The World War and the break-up of the Austro-Hungarian empire led to a disastrous decline in its foreign trade. In 1913 the sea-borne imports and exports of Fiume (together with what is now the Yugoslavian Porto Baross) amounted to 2,258,501 tons but in 1922 to only 122,126 tons. The Italian administration has been trying to regain for Fiume "her erstwhile position of predominance in the eastern Adriatic coast by a series of treaties with the chief countries in the Balkans." That some success has been achieved is shown by the fact that the figure for maritime exports and imports in 1927 had risen to 795,724 tons. "The only impediment lies in political divergencies with Yugoslavia and the totally altered economic condition of Hungary, which was bereft by the peace treaty of over 30 per cent of its best agricultural and mining territory" (see "Free Trade Zones (or Free Ports)"; *U. S. War Dept. Corps of Engineers and U. S. Shipping Board Misc. Ser. No. 3*, Washington, 1929, p. 231. This document includes a short article on the free port of Fiume.).

ASIA

French Indo-China—A Colonial Empire. "French sovereignty is like a strong iron band that holds the parts together and supports the structure." In this way Albert Sarraut describes the work of France in Indo-China. The five countries composing the union show marked differences. Tonking and Northern Annam occupy the composite delta of the Sông-cá, Sông-ma, and Red rivers. Cambodia and Cochin China are situated on the delta of the Mekong. Both are regions of lowland farmers whose chief crop is rice. Separating the two are the highlands of Laos and the Annamite Range. Before the advent of the French the nations of Indo-China had little contact with the outside world, and their interrelation was largely limited to warfare. In "Un empire colonial français: L'Indochine" (Paris and Brussels, 1929) Georges Maspero has assembled a series of articles, by authorities in each field, that supplies the physical and human background of Indo-China. In contrast we may note the appearance of a detailed study of one portion of the country—"Le Thanh Hoá," by Charles Robequain (Paris and Brussels, 1929). It deals with the northernmost province of Annam, one that includes both mountain and lowland regions. The delta supports a dense Annamite population. In the highlands, where the water supply is more precarious and where cultivable land is limited to valley bottoms, is a scattered population of a more primitive, negroid character. The contour of 15 meters forms the division line between the races. A feature of this typically French monograph is a number of aerial views of forms of settlement.

French enterprise in the lowland sections of Indo-China has shown immediate and gratifying results. In Northern Annam and Tonking 151,000 hectares have been irrigated by government projects. In Cochin China 1,250,000 hectares have been drained since 1893, and the area cultivated has been increased by 740,000 to over 2,000,000 hectares. The 2000 kilometers of drainage canals in Cochin China serve also as a cheap and efficient method of transporting freight. The interrelation between rice fields and drainage canals is shown on the map "Cochinchine, Sud-Annam, et partie du Cambodge—carte économique" (scale 1 : 500,000) prepared by the Direction des Affaires Économique de l'Indochine.

As in most marginal lands today improved transportation must precede the economic development of the more inaccessible sections of Indo-China. In southern Annam, the efficient use of the scattered area of "red lands" with their fertile, moisture-retaining soil is dependent upon highway construction. It is, however, now possible to travel over an excellent motor highway from the Chinese border to Siam, a distance of over 2500 miles. This famous Mandarin Highway passes through the capitals of all the countries of Indo-China with the exception of Laos. Roads focusing on Hanoi connect the capital of the union with all parts of the Red River delta. Roads, supplemented by canals, give access to all parts of Cochin China. At present but one road crosses the Annamite Range, connecting the Laotian town of Savannakhet on the Mekong with the coast of Annam near Hué. Other transmontane roads now under construction will supply Laos with more satisfactory access to the sea.

According to the "Rapport sur l'industrie minière de l'Indochine française in 1927" (*Bull. Écon. de l'Indochine*, Vol. 31, 1928, pp. 607–700) the value of minerals produced in Laos has increased from 25,000 piasters in 1923 to 788,000 piasters in 1927. In the summer of 1929 work was begun on the railroad connecting Thakhet with Tanap. Its completion will give added stimulus to the development of minerals in Laos. Improved transportation is also encouraging the tourist trade, a field in which Indo-China has much to offer—charming scenery, interesting people, and striking antiquities.

Several years ago A. Pouyanne presented a statement of the condition of "Les travaux publics de l'Indochine" (*ibid.*, Vol. 29, 1926, pp. 169–506). The present financial and economic situation and the projects planned for the next seven or eight years are detailed in a recent number of *L'Asie Française* (Vol. 29, 1929, pp. 233–240). The railroad from China to Siam will be completed, Laos will have railroad connection with the coast of Annam, the dikes of the Red River will be reinforced, and 230,000 hectares in Tonking and 150,000 in Annam will be irrigated.

POLAR REGIONS

Further Notes on the Antarctic Expeditions of 1929–1930. By the middle of February the four expeditions engaged in Antarctic exploration during the 1929–1930 season had virtually completed the activities whose earlier stages are briefly chronicled in the January number of the *Geographical Review* (pp. 150–151) and in *American Geographical Society Special Publication No. 11*, 1930. The Byrd expedition had made its important flights to the Pole (November 28) and eastward of King Edward VII Land (December 5) and was awaiting news from the geological party. On December 7 that party ascended Mt. Fridtjof Nansen to a height of 6500 feet, where sandstone with a layer of highly carbonaceous material was discovered. Dr. Gould identified this rock as the Beacon sandstone, exposures of which have been found at intervals along the length of the South Victoria Land horst. This discovery greatly extends the known range of the formation and adds weight to the suggestion of Sir Edgeworth David that a vast coal field underlies this part of the Antarctic ice cap. On December 13 a trek of 110 miles east-southeast from Mt.

Betty brought the geological party to 85° 27′ S. and 147° 30′ W. Because this was outside the Ross Dependency the area was claimed for the United States. The party also verified the conclusion arrived at by Admiral Byrd on early flights to the Queen Maud Mountains that the Carmen Land of Amundsen, represented on the map in his "South Pole" as a scarp running across the possible head of Ross Sea, does not exist. Instead, low shelf ice was observed extending southeast at least as far as the 140th meridian west along the outer flank of the Queen Maud Range, a circumstance that lends further interest to the suggestion that a depression may connect Ross Sea and Weddell Sea. The return trip to Little America was begun on December 31 and concluded on January 19.

Meanwhile cloudiness, characteristic of the advanced season, forced Byrd to curtail further aerial exploration. On January 20, however, a short photographic surveying flight was made to Discovery Inlet, and, the good weather continuing, on January 21 Byrd flew 100 miles west to Discovery Inlet and thence 140 miles south over the interior of the Ross Shelf Ice in search of an explanation of the existence of Discovery Inlet, that major reëntrant in the face of the shelf ice that has persisted at least since 1902. Although some 15,000 square miles were viewed, a pressure area in the ice about 100 miles south of the Inlet was the only indication that this part of the Barrier might be resting on solid ground. Later in the month a short flight was made to the Bay of Whales to photograph the striking ice gorges running west-east which may be caused by the impingement of the shelf ice upon submerged land.

The pack ice north of Ross Sea proved to be unusually slow in breaking up this year. It was not until February 7 that the *City of New York* was reported to have crossed it. Even then heavy gales forced her to the west until on February 15 Ross Island and Mt. Erebus were sighted. However, having attained the shelter of the Barrier, the vessel made good speed eastward, taking a series of soundings just off the Barrier along her course. On February 18 the *City of New York* reached Little America; the expedition was rapidly embarked, and on February 26 the ship was reported as having re-traversed the pack ice. (For press despatches on the Byrd expedition see *The New York Times*.)

The weather and ice conditions at Deception Island proving less satisfactory this season than last, Sir Hubert Wilkins embarked his expedition on the *William Scoresby*, hoping to find somewhere along the western side of the Antarctic Archipelago an ice floe large enough to serve as a base for long flights; but in this he was unsuccessful, and a pontoon-equipped plane had to be resorted to. On December 19 a flight south to Beascochea Bay and thence across the 9000-foot plateau to Richthofen Valley confirmed the discoveries of the previous year. A flight to Charcot Island on December 28 was balked by a violent snowstorm. Three days later, Wilkins took off from the side of the *William Scoresby* in latitude 67° 47′ S. and 75° 21′ W. and, circling over Charcot Island, dispelled the last doubts as to its insularity. Eastward Wilkins believed he identified Mt. Ranck and the Finley Islands north of Stefansson Strait. To the south of Charcot Island a low sloping snow-covered coast, broken here and there by bare peaks, and undoubtedly a continuation of Hearst Land, was observed to extend westward to about longitude 80° W.

Again leaving Deception Island on the *William Scoresby* on January 25, the expedition was able to pass south of Peter I Island, the pack ice lying about 30 miles south. In spite of heavy winds and seas, the edge of the pack was followed westward to about 69° 30′ S. and 100° W., when the vessel turned south. Here an attempt to fly south was frustrated by heavy snow squalls, and a course along the edge of the pack was resumed to 70° 10′ S. Bad weather and failure of the radio made this position almost untenable, but finally on February 1 the plane was launched and a course set for the south. Flying through a snowstorm over scattered ice floes and sighting large icebergs which at first appeared to be land, the aviators penetrated

to 73° S. at 101° W. Here, although their range of vision was greatly limited by a heavy storm bank, no indications of land could be observed over an area where previously land had been thought to exist. Failing another break in the weather, the *William Scoresby* turned towards Deception Island and continued her oceanographical researches en route. At Deception Island a quick shift put the party on a Norwegian whaler bound for Montevideo, which was reached on February 22.

After leaving Heard Island the *Discovery*, bearing Mawson's expedition, on December 20 crossed the Antarctic Circle at 73° 5′ E. From this point the ship proceeded westward to 66° 11′ S. and 65° 10′ E., where clear weather permitted trial of the small scout plane. From an elevation of 500 feet, low hilly ice-covered land was reported as lying 50 miles to the south. Cruising to the west, on January 4, 1930, the expedition sighted mountain peaks rising from continental ice slopes; and, on the following day in longitude 61° E. and latitude about 67° S., from the air a coast line was traced fifty miles to the east and eighty miles to the west beyond Kemp Land towards Enderby Land. The coast east of Kemp Land, where a series of rocky peaks attain several thousand feet in elevation, was named MacRobertson Land. Observations and soundings being continued in the direction of Kemp Land, it was discovered that Kemp had plotted the land seen by him in December, 1833, almost 2° too far to the north. On January 13 the expedition arrived off the coast of Enderby Land, where a landing was made. Off Cape Ann a change in the physiographic features of the coast was noted in the appearance of a striking mountain range in the distance to the west. However, a storm which forced the *Discovery* away from the land and a meeting with Riiser-Larsen (see below), at which Mawson defined his sphere of exploration as lying east of longitude 40° E., resulted in the expedition's return to Enderby Land. On the return a series of airplane flights aided greatly in mapping that land. Having delineated the coast from longitude 44° to 66° E., Mawson concludes that it is unmistakably the edge of the Antarctic Continent, and in view of the irregularity of the continental shelf he postulates a drowned coast. In general, a broad similarity exists between the rocks of this sector and of the known regions of Queen Mary and Adélie Lands, but rocky ranges rising above the general ice level are much more abundant. In fact, several definite ranges with elevations of 7000 feet were roughly charted, and one in Enderby Land was named Scott Range. A northeast gale at the end of January so depleted the quite limited coal supplies of the *Discovery* that it was found necessary to return to Kerguelen Island for refueling and therefore to cease exploration within the pack ice for the present season. (For press despatches on the Wilkins and Mawson expeditions see the *New York American*.)

Meanwhile, the *Norvegia*, which has been operating in close conjunction with the *Thorshammer* and the *Thoröy* of the Norwegian whaling fleet, reported important discoveries in the African Quadrant. These are largely the result of a series of flights by Captains Riiser-Larsen and Lützow Holm. On December 22, flying 100 miles south from the *Norvegia*, they discovered land between Enderby and Kemp Lands. Bringing their plane down on near-by open water, they skied ashore and raised the Norwegian flag. In the middle of January the aviators announced that they had mapped 370 kilometers of a long precipitous coast line extending between longitudes 55° and 43° E. Proceeding in an easterly direction the *Norvegia* met the *Discovery* on January 14. This meeting gave the two parties an opportunity of comparing their programs and of arranging further exploration so as to avoid overlap. Shortly afterwards the *Norvegia* proceeded westward and discovered the Norvegia Bank, with depths from 580 to 900 meters, in the sea between latitudes 67° 50′ and 68° S. and longitudes 32° 14′ and 33° 14′ E. Oceanographical sections were carried out from Enderby Land across the Norvegia Bank and to the north. Both Mawson and Riiser-Larsen reported the Enderby Land coast as notably free from ice. The *Norvegia* proceeded westward, but weather conditions made it impossible to use the

planes for further explorations until February 17 when the aviators charted the west coast of a new land from 71° 26′ S. and 11° 31′ W. to 71° 50′ S. and 11° 25′ W., whence shelf ice was seen stretching in a southwesterly direction. They also charted the north side of the land in an east-northeast direction to about 8° W. The 100 miles of new coast discovered are of comparatively low elevation, no peaks being seen above the ice.

WORLD AS A WHOLE AND LARGER PARTS

The High Atlas; the Eastern Alps. From time to time attention has been called in this department to current publications which, though written primarily for the mountaineer, are of broad interest to all students of mountain geography and highland life (*Geogr. Rev.*, Vol. 11, 1921, pp. 449–450; Vol. 16, 1926, pp. 667–668; Vol. 17, 1928, pp. 671–672). In this category belongs a paper by L. Neltner to which is devoted the entire number of the periodical of the Club Alpin Français for July-August, 1929 ("Notes sur le Haut-Atlas," *La Montagne*, Vol. 55, pp. 217–286; see also Jacques de Lépiney: The Mountains of Morocco: The High Atlas, *Alpine Journ.*, No. 237, Vol. 40, 1928, pp. 221–234).

During recent years a new and fascinating field for the mountaineer has been opened up in the High Atlas south of Marrakesh (Morocco City). The establishment of the French protectorate in Morocco in 1912 and the subsequent pacification of the country have made it possible for the climber to penetrate regions that, before the World War, had been visited by a mere handful of explorers, some of them in disguise. The Syndicat d'Initiative et de Tourisme de Marrakesh now aids the tourist and climber in organizing his expedition and has built trails and refuge cabins in the vicinity of Jebel Tubkal (13,665 feet), the highest point in Morocco. Visits to this part of the range may be made in complete security, in so far as conditions of public safety are concerned. Farther west, however, lofty and attractive summits still lie in a "zone d'insécurité et par suite interdite au tourisme."

As in the Central Alps, the main crest line of the High Atlas lies near the southern edge of the massif. North of the divide a relatively heavy precipitation supports a village population along the watercourses, where irrigation is possible. The villages, built of pisé, or compressed earth or clay, to the European seem squalid in the extreme. The people are known as Chleuh. "These rude massifs, difficult of approach, have molded the men who dwell among them; a rigorous process of natural selection by largely eliminating the weaklings has produced an extraordinarily agile, hardy, and uncouth (*rustique*) type." The women do most of the work, while the men go to market, "not hesitating to walk all day in order to buy a kilogram of sugar or even less and to gossip with their acquaintances." Above the villages the mountain sides are covered with *maquis* and, higher still, with sparse pasture where a few sheep and many goats pass the summer. Even the highest peaks have been climbed many times by villagers and native hunters. Hence the term "first ascent," unless qualified, may hardly be employed in regard to mountaineering in the Atlas.

South of the High Atlas and connecting it with the Anti-Atlas is the volcanic massif of the Sirwa. Here Neltner notes a curious instance of *reversed* transhumance. Much snow falls on the massif in the winter. When it melts the water finds its way into deep ravines and subterranean channels in the lava. At lower levels it issues forth at the surface throughout the entire year. "In winter the inhabitants live with their flocks at high altitudes; but in summer the lack of water drives them from the mountains and they seek the lower pastures."

The Eastern Alps, by contrast, are classic ground in the annals of mountaineering. A recent volume on this region, however, barely mentions alpinism, if it touches upon the subject at all. To this admirable coöperative work, edited by Professor

H. Leitmeier of Vienna, twenty papers on the Austrian Alps have been contributed by university professors. In the opening chapter Dr. Norbert Lichtenecker subdivides the Austrian Alps into nineteen type regions. Other articles cover minerals, rocks, structural geology, physiography, climate, plant and animal life, glacial history, prehistory, Roman history, medieval history (there is no chapter on modern history), settlement and trade routes, architecture, costumes, music, and the Alps as represented by painters (Die österreichischen Alpen: Eine zusammenfassende Darstellung (Wissenschaft und Kultur: Eine Bücherreihe hervorgegangen aus den Volkstümlichen Universitätsvorträgen der Universität Wien, Vol. 1), Leipzig and Vienna, 1928).

PHYSICAL GEOGRAPHY

Drifting Continents. In Europe the hypothesis of continental drift has been a commonplace of discussion for more than a decade, and there it has steadily gained adherents among scientists in various fields. Are American scientists different, temperamentally or otherwise, from those of Europe? One is tempted to think so, when one considers the difference in reception of the drift hypothesis on opposite sides of the Atlantic. Up to date only two outstanding American champions of the general idea have appeared: F. B. Taylor, who anticipated Wegener in ascribing mountain structures to extensive horizontal movements of the continents; and R. A. Daly, whose modification of the hypothesis is presented in his book, "Our Mobile Earth."

But, if American scientists are slow in espousing this attractive speculation, at least they are willing to discuss it freely and even sympathetically. A symposium of fourteen geologists and geophysicists—nine of them Americans and five Europeans—has been published as a book, entitled "Theory of Continental Drift" (The American Association of Petroleum Geologists, Tulsa, Okla., 1928).

W. Van der Gracht, leader of the symposium, gives an able presentation of the hypothesis, adding suggestions of his own in an attempt to meet objections to the mechanism proposed by Wegener. Van der Gracht makes the point, rightly enough, that the hypothesis must rest finally on geologic evidence and cannot be discarded through reasoning based on imperfect knowledge of geophysics. As an analogy, he cites the remarkable structure of the Alps, the existence of which geologists must admit, although no one can at present explain its origin. However, he appears to realize that the *fact* of continental drift cannot as yet be accepted beyond all doubt and that the standing of the hypothesis is improved by inclusion of a plausible *modus operandi*. In his search for available forces to which drift may be ascribed, Van der Gracht is not more successful than others before him; but he thinks the tiny known forces may be sufficient to cause continental drift if there is periodic fusion of the subcrust, as postulated by Joly. He suggests, moreover, that slipping of the outer crust during these periods of fusion may have caused geographic shifting of the poles, thus explaining glaciation in present low latitudes without actual change in position of the earth's axis, as suggested by Wegener and Köppen.

Unfortunately for these ingenious speculations, a discovery recently announced makes the Joly hypothesis highly improbable and certainly unusable for Van der Gracht's purpose. It has been found, in contradiction of long-standing assumption, that granite melts at a distinctly lower temperature than basalt ("Melting Granite and Basalt in the Laboratory," *Bull. Geol. Soc. of America*, Vol. 40, No. 1, 1929, pp. 94–95).

Objections to the drift hypothesis urged by members of the symposium are numerous and are both specific and general. Several urge the imperfect fit of continental margins supposed to have been joined before rifting in the Cretaceous. Schuchert points out that under the Wegener view the pre-Cretaceous faunas on opposite

sides of the Atlantic ought to be nearly identical, instead of having only a few similar forms in common. Willis cites the low tensile strength of rocks and urges that the Americas would have been torn to fragments in their supposed journey across the Atlantic. Chamberlin contends that all the continents have been deformed along their present margin throughout geologic time. These and other arguments Van der Gracht attempts to answer in a rebuttal at the end of the symposium. Needless to say, the major question is not settled by the discussion; but the papers serve a useful purpose in that they marshal the evidence on both sides.

In a recent paper by Arthur Holmes, the symposium is reviewed and additional arguments for the hypothesis are advanced ("A Review of the Continental Drift Hypothesis," *Mining Mag.*, April–June, 1929). References are made to the striking geologic similarities between South Africa and South America, as discussed by A. L. du Toit in his recent book ("A Geological Comparison of South America with South Africa," *Carnegie Inst. Publ., No. 381*, Washington, 1927). Holmes uses a sketch map of the continents bordering the Atlantic, showing some of the tectonic lines on each side. He emphasizes a point made by E. B. Bailey—that the Hercynian mountain front crosses one side of the Caledonian belt in South Wales and completes the crossing in Pennsylvania ("The Palaeozoic Mountain Systems of Europe and America," *Nature*, No. 3082, Vol. 122, 1928, Nov. 24, pp. 811–814). This observation by Bailey is indeed suggestive, although its full value can be tested only by future unraveling of much obscure structure in New England. Another point on Holmes's map can and must be definitely challenged. He represents the "Cape Foldings" of South Africa as ending abruptly at the west coast without change in trend. Those who, like the writer, have seen these structures in the field know that this is not the correct picture. The Cape folds extend westward in the Langeberg, bend gradually northwestward, and die out against broad folds that trend north-northwest. Between this salient and the west coast the Paleozoic sediments are disturbed only by gentle folding parallel to the coast—*the east-west structure does not carry through.* Whatever the bearing may be on the drift hypothesis, the Cape Ranges have not been broken off sharply at the coast and cannot by any stretch of the imagination be represented as having a simple structural relation to the transverse folds of Argentina.

Holmes proposes, as the motive power for drift, strong convection currents that rise in the sima and spread radially along the base of the crystalline crust, exercising drag effect. If this idea can be developed convincingly, it may remove the chief objection to the general hypothesis from the viewpoint of geophysics. In any case, as R. H. Rastall urges in another recent paper, it is proper for physics and mathematics to suspend "judgment on the problem of continental drift, until geology and other sciences of observation have shown whether such drift did or did not take place" ("On Continental Drift and Cognate Subjects," *Geol. Mag.*, Vol. 66, 1929, pp. 447–456).

More than one contributor to the American symposium ends his argument with the conclusion that the hypothesis of continental drift must be rejected. The confidence of this unfavorable verdict is as difficult to understand as the extravagance of claims made by some protagonists. Political parties and religious sects demand declarations of allegiance; but surely it is not essential, or wise, that we take definite sides with relation to every scientific hypothesis. The postulate of continental drift is a radical idea, from the viewpoint of so-called "orthodox" geology; but it must be admitted that the "orthodox" views leave many riddles unsolved. Anyone who examines the magnificent features of Permian glaciation in low southern latitudes and considers the nearly total absence of such evidence north of the equator must feel the need of some unusual explanation. Whether we like it or not, the hypothesis of continental drift is with us, not to be accepted or rejected after an academic debate but to be tested and tried by strictly impartial scientific inquiry and observation.

CHESTER R. LONGWELL

Stand of **Sea Level at the Climax of the Last Glaciation.** The amount of the lowering of sea level by abstraction of water to form the Pleistocene ice sheets has long been subject to estimates and guesses. Those before 1925 have been reviewed by R. A. Daly (Pleistocene Changes of Level, *Amer. Journ. of Sci.*, Ser. 5, Vol. 10, 1925, pp. 281–313). Here attention will be drawn to those made since 1925, because they all reach practically the same figure, though arriving at it independently and by totally different ways. The estimates will be taken in chronological order.

The undersigned (Ernst Antevs: The Last Glaciation, *Amer. Geogr. Soc. Research Ser. No. 17*, 1928) compiled the available data on area, thickness, and surface slope of the last ice sheets and glaciers and calculated the probable cubic volume of the ice in excess of the existing amount. Then the corresponding water volume and the thickness it represented, with the area of the oceans, were estimated. The ice on the northern hemisphere was found to represent a water layer 83 meters thick, and that on the southern hemisphere a water layer 10 meters thick. Therefore, if the glaciations reached their climax about contemporaneously on both sides of the equator the sea level was lowered by some 90 meters.

Submarine terraces off rivers in different parts of the world, interpreted by F. P. Shepard (Significance of Submerged Deltas in the Interpretation of the Continental Shelves, *Bull. Geol. Soc. of America*, Vol. 39, 1928, pp. 1157–1170) as Pleistocene deltas, are thought to indicate a 50-fathoms lower stand of sea level during the greatest extent of the last ice sheets.

A decade ago G. A. F. Molengraaff attempted to decipher the position of the Pleistocene sea level from the submarine topography of the Sunda Sea, a region that has undergone no crustal movements since the Pleistocene. He put it at a depth of at least 73 meters. Now J. H. F. Umbgrove (The Coral Reefs of the Thousand Islands, Java Sea [in Dutch with English résumé], *Wetenschapp. Mededeel. Dienst van den Mijnbouw in Nederlandsch-Indië*, No. 12, 1929; The Amount of the Maximal Lowering of Sea Level in the Pleistocene, *Proc. 4th Pan-Pacific Sci. Congr.*, Java, 1929, pp. 105–113) points out that the drowned river valleys do not end at a water depth of 70 meters but extend to about the isobath of 100 meters. This is the case in the South China Sea, the Java Sea, and in the Strait of Malacca. A Pleistocene ocean level below the depth of 70 meters is also suggested by the close affinity of the fresh-water fish fauna in eastern Sumatra and western Borneo, for the submarine channels of a river of Sumatra and one of Borneo join below the depth of 80 meters. The maximum lowering of the ocean level in the Pleistocene thus seems to have amounted to about 100 meters.

ERNST ANTEVS

The Variability of Annual Rainfall over the Earth. Considering its human and economic importance, the variability of the annual rainfall over the earth's surface has until recently received much less attention than it deserves. Marked fluctuations in the amount of precipitation from year to year affect crops, water supply, irrigation, navigation on rivers and lakes, health, industry, and other aspects of human life and activity. There are, of course, many districts where irrigation has accomplished much in enabling man to become, to some extent at least, independent of variations in the amount of water supplied directly from the clouds. Along this line of human endeavor a vast amount of work still remains to be done in the way of safeguarding our food supplies and in making human life safer and happier in a world where irregularities and fluctuations in rainfall are as inevitable as sunrise and sunset.

One of the first and most significant discussions of this subject was that of Gustav Hellmann ("Untersuchungen über die Schwankungen der Niederschläge," 1909), whose paper aroused much interest and was subjected to a good deal of criticism as to the methods employed in the analysis. In a recent contribution, "Die Veränderlichkeit der Jahressumme des Niederschlags auf der Erde," Erwin Biel has collected

the best and most homogeneous data from the whole world (Festband Eugen Oberhummer, *Geogr. Jahresber. aus Österreich*, Vol. 14 and 15, Leipzig and Vienna, 1929). The available material is necessarily still inadequate and scanty, but it is far ahead, in quantity and in quality, of any previously used in similar studies. It is a satisfaction to note how useful the "World Weather Records," compiled by H. H. Clayton (Smithsonian Institution, 1927), have been in making easily accessible the most important, as well as the most reliable, records for the whole world. Additional data, especially from China, Asiatic Russia, and Turkey have also been collected and used.

The basic period is that of the 40 years 1881–1920. Most of the stations have records covering this period, and shorter series were employed only when no other material was available. It is a notable fact, long recognized, that within a large climatic district or province, the variability is as a general rule independent of the mean annual amount. Hence it is possible to regard the variability at a representative station as typical for a considerable area. This naturally greatly increases the significance of the still rather discouragingly inadequate material.

The essential results of Dr. Biel's work are summarized in his chart, which, by the way, is an unusually clear and effective one. On it are shown, for the whole world, the percentage variabilities of the annual rainfall, in seven styles of shading representing variabilities of less than 10 per cent, 10–15 per cent, 15–20 per cent, 20–25 per cent, 25–30 per cent, 30–40 per cent, and over 40 per cent. In order to discover the general régime of the variability, mean values were determined for 10°-latitude intervals. It appears that "the curve of variability of precipitation over the land masses of the world is a replica of the curve of pressure distribution: the regions of low pressure have abundant rainfall and small variability; the regions of high pressure have small rainfalls and great variability. Our curve (of variability) is therefore a reflection of the curve of rainfall distribution by latitude zones. In the northern hemisphere it falls from latitude 70° to the depression at about 60°; reaches a maximum of 37 per cent in the horse latitudes; falls to 13 per cent in the meeting place of the trades in the equatorial zone; rises to 31 per cent in the horse latitudes of the southern hemisphere; falls to 12 per cent in the zone of the 'roaring forties' (this being the minimum for the world), and then apparently rises slightly again towards Antarctica." Another point investigated by Dr. Biel is that of the isanomalies, i.e. those districts whose variability departs decidedly from that of the mean of their latitudes.

R. DEC. WARD

HISTORY OF GEOGRAPHY AND EXPLORATION

The Portolan Chart of Angellino de Dalorto, 1325. Students of early maps will be indebted to the Royal Geographical Society of London for a very pleasing facsimile in color of the portolan chart of Angellino de Dalorto, 1325, now in the collection of Prince Corsini at Florence. This is announced as the first of a series of reproductions of manuscript maps. In a pamphlet accompanying the reproduction, Arthur R. Hinks, Esq., Secretary of the Society, explains why the Dalorto map was chosen to initiate the series: "Of the eight portolan charts of the normal type of the fourteenth century or earlier I was able to compare seven, and of these seven the Dalorto map seemed to be without doubt the most valuable to students, a portolan chart of the best style, in beautiful condition . . . , with the beginnings of the later elaboration, and individual features of merit, especially in the land geography."

Very little is known about the origins and antecedents of these surprisingly accurate navigators' maps of the Mediterranean and Atlantic coasts of Europe and North Africa which made their appearance rather mysteriously toward the end of the thirteenth century. Mr. Hinks describes their common characteristics and gives brief, non-technical notes on each of the surviving portolan charts and related

Catalan world maps and atlases of the fourteenth century. With one exception all of these maps have been reproduced—some well, some poorly—and described in considerable detail, especially by Konrad Kretschmer (Die italienischen Portolane des Mittelalters, *Veröffentl. Inst. für Meereskunde*, No. 13, 1909, Berlin). The one exception is an anonymous fourteenth century chart, of no little interest, now in Prince Corsini's possession.

METHODOLOGY

Isopleth as a Generic Term. While geographers, meteorologists, and others who make use of graphic representation have coined a vast number of specific terms for lines of equal value—isobar, isobase, and the like—no generic term yet appears to have met general recognition. "Isopleth," which has been used on Mr. C. J. Bollinger's map of Population Density in Central Oklahoma elsewhere in this number of the *Review*, would seem acceptable in its derivation. The root "pleth," signifying degree of fullness or quantity, has recognizable relations in such words as "plethora." It is quite familiar among geographers of English speech (compare letter from H. S. Palmer to *Science*, No. 1789, Vol. 69, 1929, April 12, p. 402). Griffith Taylor writes us that he first used the word for lines of equal population density in the first edition of his "Australia" (1911) but, finding it already employed for lines of equal abundance, adopted it as a generic term.

Among meteorologists, however, as Talman has pointed out (*Monthly Weather Rev.*, Vol. 43, 1915, pp. 195–198) there has been a tendency to restrict the meaning to "a line showing the variation of an element in relation to two coordinates; one of the coordinates representing the time of the year (month), and the other usually the time of day (hour), but sometimes space (especially altitude)." An interesting example of such an application by Guy-Harold Smith appears in *Science* (*loc. cit.*, pp. 404–405) under the title "A Three-Dimensional Thermoisopleth." In its representation of surface instead of line it resembles a block diagram.

Sir Napier Shaw, who used "isopleth" generically in the first edition of "Forecasting Weather" (1911), replaces it with the less descriptive "isogram" in the second edition (1923). "Isogram," which is favored by Talman, was suggested by Sir Francis Galton (*Nature*, Vol. 40, 1889, p. 651), who incidentally was the originator of one type of isogram or isopleth, the isochronic line or isochrone (Francis Galton: On the Construction of Isochronic Passage-Charts, *Proc. Royal Geogr. Soc.*, Vol. 3 (N. S.), 1881, pp. 657–658). Alfred C. Lane and Eric R. Miller bring forward "isogram" in a letter to *Science* (No. 1786, Vol. 69, 1929, March 22, p. 330) following an earlier communication by Dr. Lane proposing "isontic" (*ibid.*, No. 1750, Vol. 68, 1928, July 13, p. 37). Against this last suggestion it may be argued that the second root "ontic," implying merely existence, is not distinctive enough and that, because of the close amalgamation with the first root, "iso," the meaning is not self-evident. Professor Davis' "ontology" is an instance of a similar word which has not established a general footing.

Among German and Scandinavian geographers "Isarithmen" is in common use, though Eckert—and he is followed by Hettner—does not regard it as any too happy an expression. Eckert in "Die Kartenwissenschaft" (Berlin and Leipzig, 1921), gives many examples of the application of "isarithms" in population density maps and in his index has a voluminous list of specific terms belonging in the general category of isarithms.

GEOGRAPHICAL NEWS

Foundation of the Canadian Geographical Society. The inaugural meeting of the Canadian Geographical Society was held in Ottawa on January 17 under highly auspicious circumstances. His Excellency, the Governor-General of Canada, Vis-

count Willingdon, speaking as Honorary Patron of the Society, commended its organization. "With Canada winning for herself an ever-increasingly important place among the nations of the world as the years pass it is only fitting that such an organization as the Canadian Geographical Society should be formed to better acquaint Canadians with their own and other countries." Greetings from the Royal Geographical Society were brought by Sir Francis Younghusband, who also delivered the inaugural lecture. This, an account of his epoch-making visit to Lhasa in 1903, filled with human interest and vivid with picturesque descriptions, marked him "not only a distinguished traveler but a philosopher and seer as well," as Dr. J. Mackintosh Bell observed in voicing the appreciation of the audience.

The good wishes of the American Geographical Society were expressed by its Director, Dr. Isaiah Bowman, in giving promise of hearty coöperation. "We have always admired the splendid work of your geographers and explorers," he said, "and on occasion we have been privileged to publish some of their results in the *Geographical Review*. The names of several distinguished Canadians stand upon our honor roll of gold medalists. It has long been obvious that under the stimulus of your own organization your distinctive work would reach a far larger scientific audience and become of wide popular interest as well."

The avowed object of the Canadian Geographical Society is "to make itself a real force in advancing geographical knowledge and in disseminating information on the geography, resources, and peoples of Canada. In short, its aim is to make Canada better known to Canadians and to the rest of the world." The Society is fortunate in its President, Dr. Charles Camsell, Deputy Minister of Mines, who has a rich personal knowledge of the Canadian North and a thorough acquaintance with its manifold problems. Mr. J. B. Tyrrell is Honorary President, Dr. A. P. Coleman is Honorary Vice-President, and the directorate numbers a long list of men well known in Canadian affairs. As one of the major instruments for carrying out its purpose the Society will publish a monthly magazine, the *Canadian Geographical Journal*.

OBITUARY

NAOMASA YAMASAKI. Dr. Naomasa Yamasaki, professor of geography in the Tokyo Imperial University, died on July 26, 1929, in the sixtieth year of his age. From his return to Japan in 1902 after three years of geographical study in Europe Dr. Yamasaki worked actively for the advancement of geography in his country. He was the first incumbent of the chair of geography established at the University in 1911 and was president of the Association of Japanese Geographers, founded in 1923; he was a member of the Imperial Academy, of the National Research Council, and of the Imperial Earthquake Investigation Council. These several bodies he represented at numerous scientific congresses. As illustrative of his activities may be mentioned his "Geographical Sketch of Japan" in the volume "Scientific Japan" issued on the occasion of the Third Pan-Pacific Science Congress, Tokyo, 1926; "A Note on the Geographical Distribution of the Density of Population, Birth- and Death-Rates of Japan" presented before the Second Conference of the Institute of Pacific Relations, Honolulu, 1927; and the paper "Acute and Chronic Tilting of Land Blocks in Japan" read before the International Geographical Congress at Cambridge, 1928, of which he was a Vice-President.

An obituary notice by T. Ogawa in the *Proceedings of the Imperial Academy* (Vol. 5, Tokyo, 1929, pp. xviii-xx) speaks of the "enduring value" of Dr. Yamasaki's contributions to "the fields of inquiry where geology and geography overlap." These inquiries include some notable investigations on glaciation in the Japanese Alps but particularly his physiographic studies on earthquake phenomena, an example of which is the excellent "Physiographical Studies of the Great Earthquake of the Kwanto District, 1923" (discussed in *Geogr. Rev.*, Vol. 17, 1927, pp. 495–496).

COLONEL SIR THOMAS HUNGERFORD HOLDICH. Sir Thomas Holdich, "maker of boundaries," died in Surrey, England, on November 2, 1929, in the eighty-seventh year of his age. Sir Thomas began his career in India in a classic region of frontier operations that he has so well described in "The Indian Borderland" (1901) and "The Gates of India" (1910). In 1884 he was chief of survey on the boundary commission for settling the Russo-Afghan boundary. From 1892 to 1898 he held the position of Superintendent of Frontier Surveys in India, during which time he was engaged in demarcation of the eastern boundary of Afghanistan, 1894, and in 1895 and 1896 was occupied with the Pamir Boundary and the Perso-Baluchistan Boundary Commissions respectively. Such was his reputation that he was appointed on the Tribunal of Arbitration in one of the most famous of boundary cases—that between Chile and Argentina at the beginning of the twentieth century. Of his experiences in that capacity "The Countries of the King's Award" (1902) is a delightful and informing souvenir.

To the scant literature on the broader question of principles and theories in boundary making he has contributed "Political Frontiers and Boundary Making" (1916) and "Boundaries in Europe and the Near East" (1918). His views naturally were decided: "the best way to preserve peace amongst the nations is to part them by as strong and as definite a physical fence as can be found" (D. W. Johnson: The Rôle of Political Boundaries, *Geogr. Rev.*, Vol. 4, 1917, pp. 208–213).

Sir Thomas Holdich was a gold medalist of the Royal Geographical Society (1887), in which he held various offices including that of President (1916–1918). He was an Honorary Member of the American Geographical Society.

GEORGE GOUDIE CHISHOLM. Professor Chisholm died in Edinburgh on February 9, 1930, in the eightieth year of his age. He was a pioneer in commercial geography, organizing a mass of data and developing a body of scientific principles in that field. His "Handbook of Commercial Geography," which has gone into its eleventh edition and has seen many more printings since it first appeared in 1889, may truly be described as a classic. It bears the unmistakable stamp of its author, broad-minded, practical, and "eminently sane." Here and in his numerous articles in geographical magazines the discussion is always controlled by facts; and the facts are selected under a guiding philosophy that he has expounded, for instance, in an address, "The Goal of Commerce," the Herbertson Memorial Lecture for 1924 (*Geogr. Teacher*, Vol. 12, 1923–24, pp. 333–342) and more recently in the essay "World Unity" (*Geogr. Rev.*, Vol. 17, 1927, pp. 287–300). Professor Chisholm's view of the nature of geography may be illustrated by quotation from the preface to the ninth (1922) edition of the Handbook: . . . "the constraining influence of geographical conditions and the multiform modes of that influence. In saying this I do not mean to hint that man has no control over his own destiny. But he must stoop to conquer. To subdue nature he must submit to nature's laws, and the more reverently he does so the better will it be for him. With the passing of the centuries he can indeed go further and further in that conquest. But at all times the earth says 'Thus far and no further'; and it is impossible to foresee a time when we shall be able to look upon geographical studies as superfluous."

Professor Chisholm contributed to the promotion of geographical studies as a teacher no less than as a writer. When a lectureship in geography was established in the University of Edinburgh in 1908 he was appointed to the position and held it until 1921 when a readership was created which he held until 1923. He was the recipient of many honors, including the Charles P. Daly Gold Medal of the American Geographical Society conferred upon him in 1917.

GEOGRAPHICAL REVIEWS

The St. Lawrence Question

H. G. Moulton, C. S. Morgan, and A. L. Lee. **The St. Lawrence Navigation and Power Project.** xvi and 675 pp.; maps, diagrs., index. The Brookings Instn., Washington, D. C., 1929. $4.00. 7½ x 5½ inches.

No other study has so well covered all phases of this project, and, while the conclusions of the authors are necessarily based on estimates, concerning which there is bound to be a difference of opinion, depending on the experience, temperament, and inclination of the estimator, the exhaustive character of their investigation is so evident that their conclusions cannot be disregarded, even though contrary conclusions on certain aspects of the problem may be drawn from the data submitted.

As to power, the report says, "Although the development of the St. Lawrence hydroelectric energy will in the course of time doubtless be economically profitable, its exploitation at present would be premature. The United States share [1,000,000 horse power] of the energy to be developed in the International Rapids section could not be disposed of in existing markets at a price sufficient to cover its cost of production and distribution. Its profitable marketing in the future will depend primarily upon an extensive industrial development, particularly in electrochemical and electrometallurgical lines, along the American side of the river. The conclusion with reference to Canada's enormous power resources in the St. Lawrence [4,000,000 horse power] is similar. . . . Canada has great additional power resources which many believe should be developed before tapping those of the St. Lawrence."

The report points out that only one-sixth of the available water power resources of Quebec, outside the St. Lawrence, have been developed, and about one-quarter of those of Ontario. "In Quebec, the development of power resources has been conducted by private enterprise, on the basis of government leases," so that both the government and the power companies are opposed to the development of the 3,000,000 horse power along the St. Lawrence in that province, under the auspices of the Dominion Government. On the other hand, in Ontario the Hydro-electric Power Commission, which controls the power resources of that province, favors the development of its 1,000,000 horse power in the International Rapids section of the St. Lawrence and takes the position that the Ontario market is capable of absorbing this power as rapidly as it can be developed. It is evident, however, from the careful investigation made by the authors and their engineering experts, that there is no economic necessity for the development of St. Lawrence power at the present time, particularly as the Canadian Government is opposed to the export of hydro-electric power.

As to navigation, perhaps the most satisfactory recommendation of the authors is to adopt 27 feet as the most suitable depth of channel, although they point out that this depth "would not, however, make the St. Lawrence a great thoroughfare for ocean commerce and it would not make Cleveland, Detroit, and Chicago maritime rivals of the great Atlantic ports." This depth (with 30 feet over lock sills to permit future deepening of channel) was recommended in 1926 by the Joint Board of Engineers representing the United States and Canadian governments and by the Department of Commerce in 1927 in its publication "Great Lakes-to-Ocean Waterways"; and these channel and lock depths pertain to the Welland Ship Canal, now nearing completion.

The cost of the St. Lawrence waterway for navigation is estimated on conservative lines. To the cost of $184,659,000 estimated by the Joint Board of Engineers the

authors have added 16 per cent for interest during construction and 20 per cent to this total for contingencies, making a total of $257,000,000. This and certain other charges as the estimated cost of improvements are given below:

Improvements in the St. Lawrence River	$257,000,000
Improvements in Lakes (channels)	90,000,000
Provision of harbor and port facilities (Lakes)	250,000,000
Cost of Welland Ship Canal	115,000,000
Total	$712,000,000

As to annual cost of operating, the authors charge 4 per cent interest and 1 per cent depreciation and certain other annual expenses as follows:

Interest and depreciation on $712,000,000	$35,600,000
Operating locks at the Soo, Welland, and St. Lawrence	2,500,000
Maintaining channels in Great Lakes	1,000,000
Maintaining harbors in Great Lakes	500,000
Maintaining St. Lawrence channels	500,000
Administration	500,000
Total annual charges	$40,600,000

The authors expect these annual charges to be covered by the traffic passing through the St. Lawrence waterway, which they estimate at 10,500,000 tons. This, it may be noted, is only half that estimated by the Department of Commerce in the publication already cited and a third of that estimated by the Great Lakes–St. Lawrence Tidewater Association; it compares with 7,321,348 tons which in 1928 traversed the entire length of the present St. Lawrence canals, having a depth of 14 feet.

In view of the estimated costs and traffic, it is not surprising to find that the authors conclude that "the annual overhead charges against the waterway, that is, interest and depreciation on the capital investment and maintenance and operation of the route, would amount, when figured on the most conservative basis, to approximately $40,000,000 . . . which means that the tax-payers are to contribute about $3.50 a ton for the benefit of such shippers as would use the route. . . . Thus, in order to effect a reduction of 4 cents a bushel in the cost of moving grain, tax-payers in general would have to contribute approximately 11 cents a bushel."

But is this a correct deduction from the authors' own data? It is not clear why the improvement of channels and harbors on the Great Lakes and the cost of the Welland Ship Canal should be charged solely against the comparatively small tonnage moving over the proposed St. Lawrence waterway. The deepening of lake channels and harbors, if made, will not be on account of this small tonnage but on account of the increasingly heavy traffic on the Great Lakes, now 150,000,000 tons a year. The Welland Ship Canal was not built by the Canadian Government as part of the improvement of the St. Lawrence—in which it is showing little interest—but to make cheaper the passage from the upper lakes to Lake Ontario, and to Montreal by permitting lake carriers to continue to the upper St. Lawrence.

The authors recognize that deepened lake channels and harbors are not necessarily a part of the improvement of the St. Lawrence when they say: "Our investigation has shown that the lake carriers are more economical than the ocean boats. . . . All the transportation economies between the upper lakes and Montreal that can be effected could be realized by means of a 22-foot channel. Such a depth of channel would involve no substantial improvements of existing inter-connecting lake channels or of lake harbors. . . . The reductions in grain rates that would be effected by enabling ocean carriers to enter the Lakes, or lake boats to move down to Montreal would be at most 4 cents a bushel."

It would therefore seem fair to charge against the 10,500,000 tons estimated to move over the proposed St. Lawrence waterway only those items which pertain directly to this improvement, as shown below:

Interest and depreciation on $257,000,000	$12,850,000
Operating St. Lawrence locks	833,000
Maintaining St. Lawrence channels	500,000
Administration	167,000
Total	$14,350,000

This is equal to $1.37 a ton on the estimated tonnage, equivalent to 4 cents a bushel, which is the estimated saving to be effected by the improvement.

As the estimated tonnage is conservative—only half that of the Department of Commerce, and only 50 per cent more than that carried in 1928 by the present St. Lawrence canals of 14-foot depth—and as the traffic is certain to increase, while the heavy operating charge (interest and depreciation) remains fixed, it is reasonable to conclude that the proposed improvement of the St. Lawrence River for purposes of navigation is economically sound.

PHILIP W. HENRY

THE DISTRIBUTION OF NATURAL RESOURCES IN MINERALS

J. W. FURNESS, L. M. JONES, AND F. H. BLUMENTHAL. **Mineral Raw Materials: Survey of Commerce and Sources in Major Industrial Countries.** vii and 278 pp.; diagrs., bibliogr., *Bur. of Foreign and Domestic Commerce, Trade Promotion Ser. No. 76*, Washington, 1929. 45 cents. 9 x 6 inches.

Sir Thomas Holland, in his presidential address before the British Association for the Advancement of Science at Cape Town, remarked that by the beginning of the twentieth century the industrial activities of the world had entered "a new phase which was characterised, if not dominated by the necessity for minerals to maintain the expanding arts of peace" . . . "that natural resources in minerals now set a rigid limit to power whether industrial or military." And his recent lecture "International Movement of Mineral Products in Peace and War" (*Journ. Royal Soc. of Arts*, Vol. 78, pp. 373–391) is an exposition on the "basic fact that no country is self-contained in the matter of mineral resources." These notes are being sounded with increasing frequency in discussions of mineral resources and their exploitation. The introduction to the bulletin under review states that the subject has been approached from the standpoint of international trade, not from that of the mining engineer or the geologist.

The work is prefaced by two charts, the first showing the ability of a country to supply its needs of the principal minerals from within its own boundaries, and the second the combined resources within the country itself, as well as the reserves controlled by it. The eight countries selected for consideration are the United States, Germany, France, the United Kingdom, Japan, Belgium, Italy, and Spain, as they together consume about 80 per cent of the world's total production of minerals. Part I, entitled "Survey by Countries," is an elaboration of these charts. Each country is treated separately, indicating its requirements in each of the twenty-eight selected minerals (constituting by far the larger part of the monetary value of minerals now used industrially), the amount of the home production, and the imports and exports of these minerals for the five years 1923–1927. The location of the home deposits and the sources of the imports are also indicated. A graphic chart is appended at the end of the text on each country, summarizing the conclusions drawn. In Part II, "Survey by Minerals," each commodity is treated separately in relation to the general world position of the various minerals and the relative position held

by the eight countries under review with regard to the production and consumption of each commodity. Graphs are given showing the exports, production, and imports of the major consuming countries in 1926. To these are added paragraphs on the principal uses of each commodity and prices for the years 1923–1927. In conclusion there is a table showing countries and districts from which the major world shipments of the various minerals have been derived. This drives home the geographical distribution and the fact that the chief consuming countries draw their supplies from a limited number of districts. None of the eight countries considered, not even the United States, has sufficient supply, within its own borders, of all the minerals necessary for its industrial prosperity.

E. Muriel Poggi

Mineral Resources of Michigan

B. S. Butler and W. S. Burbank. **The Copper Deposits of Michigan.** xii and 238 pp.; maps in separate case, diagrs., ills., bibliogr., index. *U. S. Geol. Survey Professional Paper 144*, Washington, 1929.

F. G. Pardee, O. F. Poindexter, and R. B. Newcombe. **Mineral Resources of Michigan, with Statistical Tables of Production and Value of Mineral Products for 1924, 1925, 1926, and Prior Years, with a Report on Oil and Gas Development.** 321 pp.; maps, diagrs., indexes. *Michigan Geol. Survey Publ. 37, Geol. Ser. 31*, Lansing, 1928.

One hundred years ago Douglass Houghton first visited the native copper deposits of northern Michigan. His report, issued in 1841, initiated an active exploitation of this area, which has placed Michigan second among the copper-producing states with a total production, in 1925, of seven and one-half billion pounds of refined copper. Even now the thoroughly prospected area is but a small part of the mineralized zone—that narrow belt, two to four miles wide and one hundred miles long, which is commonly called the Copper Range. The cost of obtaining geological information is high because of the heavy glacial drift that overlies the Range. It has been desirable, therefore, to collect and put on record all such data as are available in the hope of promoting effective planning of future developments. This has been accomplished in "The Copper Deposits of Michigan," which, with its folder of 51 maps and cross sections, its very extensive bibliography, and its excellent section on the genesis of copper, represents the composite work of the U. S. Geological Survey and the Calumet and Hecla Mining Co.

The Report on the "Mineral Resources of Michigan" for 1924–1926 incorporates a study of the oil and gas developments in the state. Here, as in the case of copper, the heavy cover of glacial drift makes it difficult to learn of the surface rock conditions. Considerable wildcat drilling throughout the Lower Peninsula has resulted in the discovery and opening up of the small Saginaw Oil Field, which reached its highest production in June, 1927, with a daily flow of 1400 barrels, and of the Muskegon Oil Field, which has an average production of 75 barrels a day from the fifteen producing wells.

Water Power Development in the United States

W. H. Voskuil. **The Economics of Water Power Development.** xii and 225 pp.; maps, diagrs., bibliogr., index. McGraw-Hill Book Co., Inc., New York and London, 1928. $3.00. 8¼ x 5½ inches.

This presentation of the developed and potential water power of the United States should be a boon to many who desire some knowledge of the facts and problems of water power but have not had the time to delve deeply into the subject.

The problems of the country are discussed under five headings: the northeastern states, including the St. Lawrence Valley; the southeastern states; the Colorado River; the California Valley; and the Pacific Northwest, including Alaska. Neglecting the logical order of presentation it may be useful to call attention somewhat haphazardly to those portions of the discussion that have been forced upon the public by newspapers, public debate, or Congressional action. Here may be listed: (1) a concise statement of the Muscle Shoals problem from its inception, with a summary of the arguments for government operation and for disposal; (2) the textile industries of New England and the South, presented somewhat unsatisfactorily, however, since the situation is not really a water power question; (3) the Colorado River power situation with its distant markets suggesting the limits of feasible development; (4) the question of the public control of water power; (5) the defunct Giant Power plan for Pennsylvania and the dormant Super-Power plan for the area Boston to Washington, illuminated by a discussion of the Hydro-electric Power Commission of Ontario.

Whenever tabulations are possible they have been inserted, and these which form in some cases the conclusions and in others the bases of arguments are an important part of the book.

ROBERT M. BROWN

JOURNEYS IN CENTRAL AMERICA

FRANZ TERMER. **Berichte über Reisen in Mittelamerika.** Ills. *Mitt. Geogr. Gesell. in Hamburg*, Vol. 38, 1927, pp. 3–55, 407–423; Vol. 39, 1928, pp. 1–63; Vol. 40, 1929, pp. 9–42.

Dr. Franz Termer has presented a wealth of detailed descriptive material in this series of articles, the titles of which are: Bericht über eine Reise durch das westliche Guatemala, Chiapas, und Tabasco, 1925–1926; Bericht über eine Reise durch die Sierra Madre Westguatemalas; Bericht über eine Reise durch das Kettengebirge des nordlichen Guatemala an den Golf von Amatique; Bericht über eine Reise durch die zentralen Gebiete Guatemalas; Der Atitlan-See; Eine Reise durch Honduras. The narrative style is used, most of the discussion being an expanded diary; and this has given the writer wider range of treatment than would have been possible if a more systematic scheme had been adopted.

In the first three articles Dr. Termer repeatedly emphasizes the fact of the youthful stage of development of the mountains of northwestern Central America and the adjacent portions of Mexico. He points out that evidences of recent uplifts and of lava outpourings are found nearly everywhere and that well defined terraces border all the larger streams. The reports are not confined, however, to physiography but deal with nearly all aspects of plant, animal, and human life, giving prominence to the various incidents which the writer experienced in the field.

In the fourth article Termer suggests that the most favorable areas for studying the aboriginal Indians of Guatemala are in the west-central parts of the country. Several years of residence there and a knowledge of the Indian language are essential in order to bring to light the obscure remnants of old customs and usages that still prevail carefully guarded from the eyes of strangers.

Lake Atitlan, Guatemala, is the subject of the fifth article. The east-west length is given as 20 kilometers, the north-south width as 8 kilometers, and the area as approximately 125 square kilometers. Termer upholds the view that the lake was caused by lava flows obstructing a former headwater valley of the Motagua River; he does not subscribe to the idea that it may be a huge crater. That the water level of the lake is gradually falling is evidenced by the recession of the shore line and the appearance of islands. The drainage basin is small, and the streams that flow into the lake are chiefly from the north. Owing to variability in the local rainfall the water

level fluctuates rather sharply; for example, in October, 1923, the level rose two feet in three days. There is no surface outlet, and, although no direct evidence of any subterranean outlet has been discovered, it is probable that such exists. Surrounded by highlands the basin has a slight rainfall, and the natives have learned to practice irrigation on a small scale. The author attempts to give an analytical geographical study of a small area, and hence he presents numerous illustrations of the environmental influences upon the customs and activities of the people. For example, he suggests that the ancient types of canoes, the materials used in their construction, and the manner in which they are used are due to the environmental conditions.

In the sixth article, Termer discusses similarities and contrasts in the physiography and life responses in western Guatemala and Honduras. The cross-roads location of Zacapa as a trade center is emphasized. The terraces along the Motagua are described briefly. The description of Copan and its famous Mayan ruins is the feature of this article, and the writer makes a plea for the preservation and further study of this famous temple. The article closes with somewhat extended description of the prominent terraces found along the streams of Honduras. In this he specifically refers to the discussion by Bengtson (*Geogr. Rev.*, Vol. 16, 1926, pp. 403–413) but reports that no high-lying peneplains were observed near Copan or Santa Rosa. In this there is no disagreement, since the peneplain development referred to was described for the area near Yuscaran much farther east.

The series as a whole furnishes valuable material for a part of Central America but slightly known even to geographers. The articles are not highly technical, but explanations of phenomena or relationships are not given as fully as might be desired. Dr. Termer takes the rôle of a traveler-philosopher, deftly touches upon nearly every conceivable subject, and presents the many-sided discussion in a style that holds the interest of the reader throughout.

NELS A. BENGTSON

LANDSCAPE TYPES ABOUT THE SOUTHEASTERN BALTIC

BOGDAN ZABORSKI. **Carte des types de formation superficielle des plaines de la Pologne, de l'Allemagne orientale et de la Lithuanie.** Scale 1:1,250,000. Warsaw, 1928.

This map, printed in half-tone, gray and black, covers much of Poland and part of eastern Germany and of Lithuania. It is based largely upon the German maps on a scale of 1:100,000 and on the Polish maps on a scale of 1:84,000. Below the map is a descriptive text, about 800 words in length, in Polish, in French, and in German.

The purpose of the map is to show by means of symbols the various types of topography which constitute this region. The classification is entirely empirical, though it is suggested in the text that a student of morphology might deduce the origin of most of the forms and interpret the map in terms of glacial movement and recognize the position of the ice at different stages as well as the courses of glacial rivers. Fifteen types of topography are recognized, and these are shown on the map by different tones of gray, by ruling, by dots, by crosshatching of several kinds, and by other symbols. Flat valley floors constitute one type; terrace landscapes, a second; upland plains, a third; undulating landscapes, a fourth; and lacustrine plains, a fifth. Escarpments are indicated by a special symbol, and gentle slopes by another. Ravines, dunes, isolated hills, groups of hills lying parallel to each other constitute several other types. Around the margin of the large map are twelve or more reproductions of parts of topographic sheets, in contour, illustrating practically all the types distinguished on the larger map. Were it not for these there would be some doubt as to just what characteristics are displayed by each type of landscape.

In any map of this kind a difficulty arises from the fact that landscapes not only grade into each other but also that several forms occur together, as when isolated

hills surmount a lake-dotted plain, and ravines dissect an upland plain. This means a complex intermeshing of many symbols. It might seem at first that all of this detail might better be expressed simply by contours, in which case no symbols would have to be kept in mind. That is probably true on maps of a scale so large that contours would not have to be too much generalized. But on a map like this, having a scale smaller than 1:1,000,000, the device is probably justified.

To the student of human geography who is interested in correlating landscape forms and character with human activities, a map of this type might serve admirably as a base for the plotting of geographic data of various kinds.

A. K. Lobeck

The Atlas of Finland

Atlas of Finland, 1925. iv and 320 pp.; maps, ills.; separate volume of 38 maps. Geogr. Soc. of Finland, Helsingfors, 1925–1928, 1929. 550 FMK. Text, 10 x 7 inches; maps, 18 x 13½ inches.

In 1899 the Geographical Society of Finland published an atlas of Finland which was revised in 1910. Accompanying the latter edition were two volumes of text printed not only in Finnish and Swedish but in French. The work marked a level of geographic attainment reflecting the highest credit upon its sponsors and representing a cartographic achievement ranking with the best of other nations and superior to most. Once more the Finnish leaders in science and government determined that the world should have an up-to-date accurate graphic record of the character of their country, and accordingly a revised atlas has just come from the press.

The new edition is issued under the date 1925, because most of the content is based upon statistics for that year. Like its predecessor, it presents a series of maps not only interesting but in many instances beautiful and even inspiring. Numerous digressions from the former work are conspicuous. Although large numbers of the maps deserve direct consideration, only a few are noted here in particular.

A chart indicating comparative areas of Finland and other countries of Europe shows the country to be larger than most persons would probably suspect. In fact, the country ranks among the largest, if Soviet Russia be excluded.

A four-sheet political map (1:1,000,000) allows of easy reading of details. The bathy-orographical, geological, and "surface deposit" maps (1:2,000,000) are revised at many points and printed as attractively as before. Of especial merit is the four-sheet map (1:1,000,000) showing vegetation and distribution of population. The minute detail portrayed in seven harmonious shades of color, with some variations in design, arouses one's admiration not only for the technique of the cartographer but for the enormous amount of work accomplished by the Geographical Society and the government in bringing together the data to make such a map possible. Furthermore, it offers the basis for interesting studies in human settlement, in vegetation distribution, in certain effects of the continental ice sheet, and still other relationships.

An interesting series of small regional maps portraying natural units, political units, "man-made forms," "water regions," and other types not only provide valuable data but, for the geographer concerned with methods for establishing regions and representing them in map form, suggest new ideas, controversial though they may be.

Foreign trade data are presented not only in diagrammatic form but also in maps. World maps for exports and imports reveal these items on the basis of their respective value per inhabitant of the country with which the trade is transacted. Colors in varying intensities indicate the approximate amount of trade with each country.

Distribution of libraries, educational institutions, public baths, dentists, ecclesiastical divisions, election returns, telephones, passenger traffic, agricultural organizations, and banks are only a few of the numerous diverse subjects treated by maps in this atlas in addition to the usual physical and political data which one might expect.

The French edition of 1910 has now been replaced by an English edition. The atlas proper incorporates all explanatory matter in three languages, namely, Finnish, English, and Swedish, while the accompanying text printed in a separate volume includes only a single language.

The text consists of a compilation of articles, written either by those who did the work of editing the maps of a particular subject or by those who were in charge of bureaus under whose jurisdiction the work was carried out, and each accordingly is supported by the nation's best authority. The text not only describes the basis for the maps but interprets the facts shown.

The English translation from the difficult Finnish language is well done on the whole. However, one feels that so important an undertaking deserves even more care. Had the various sections been submitted to persons whose native tongue is English, most of the unfortunate errors could have been eliminated. While these errors are not serious, nevertheless one regrets the introduction of any avoidable element which mars even slightly the beauty of the work.

A number of variations from the 1910 edition of a mechanical nature are apparent. For example, statistical tables appearing in the front part of the former atlas have been transferred in the revision to the text, and in place of these tables a helpful index has been inserted and the table of contents presented in each of the three languages. Although the number of pages devoted to maps and cartograms is fewer than in the 1910 volume, the total number of maps is somewhat greater. This increase has been accomplished mainly by reductions in size. However, in no case have such reductions affected the service of the maps.

Proponents of the dot method in cartography will wish that this device had been used in the many maps of distribution. With few exceptions block shading is employed.

The quality of paper seems to be somewhat lower than that used in earlier editions. Certainly the surface finish is not so smooth nor so white. Hence the register of color and type is not so clean-cut. A country in which the production of paper plays a vital part in its economic existence might have given this aspect more careful consideration.

In spite of these few apparent shortcomings, the atlas is a work in which the members of the Geographical Society of Finland and all others who were associated with its preparation may take rightful pride.

EUGENE VAN CLEEF

REGIONAL AND HISTORICAL STUDIES IN THE FRENCH ALPS

ANDRÉ ALLIX. **L'Oisans: Étude géographique.** xxvi and 915 pp.; maps, ills., diagrs., bibliogr. Librairie Armand Colin, Paris, 1928. 100 fr. 10 x 6½ inches.

ANDRÉ ALLIX. **L'Oisans au Moyen-Age: Étude de géographie historique en haute montagne d'après des documents inédits suivie de la transcription des textes.** 255 pp.; map, bibliogr. Librairie Ancienne Honorè Champion, Paris, 1929. 9 x 5½ inches.

One has hesitation in uttering anything but praise of so monumental a task as that accomplished by Allix in his recent volume on the Oisans. It might well be regarded a work of a lifetime, and yet Allix is a young man. But if exhaustive it is also exhausting. The volume is even too thick to be read while held in the hand. The work approximates a book on the principles of mountain geography exemplified by a single region. Perhaps it might have been more selective in the materials offered, but we cannot help admiring its thoroughness and its scholarship.

The Oisans is a well defined region in the High French Alps. The mean altitude of the area is 1000 meters, and the surrounding peaks rise to 4000 meters. Magnificent

glaciers impend the valleys, and the view of the ice-covered Meije from above La Grave is counted by the reviewer as one of his great adventures.

Allix, now in charge of the geographic work of the University of Lyon, is a protégé of Raoul Blanchard and a confirmed member of the school of alpine geographers. True to the school's tradition he starts his thesis with a chapter on geology. We are told of gabbros, the Trias, and faults within the crystallines which have little human significance. Again, we find reference to fossil peneplains which have little or no life relationships. Are we not as geographers called upon to select such elements of geology and physiography as we can use in indicating causal relationships and there cease our encroachment on the physical sciences? We must look on geology and physiography as basic data for geographic conclusions, for we hasten to admit that it is physical circumstance that has created the individuality of life responses in the Oisans.

The chapter on climate is a storehouse of truly geographic information. A device (p. 118) to show the possible insolation at given points is remarkably clever. But in the chapter on glaciers the author lapses into glaciology. It is an excellent chapter but extraneous to the geography. With the chapter on the waters the author returns again to geographic matters with which he consistently and lucidly maintains contact to the end of the book.

The second part treats in turn the settlement, occupation of the soil, habitat, rural economy, transportation, tourism, mines, manufacturing, and population. In treatment this alpine school has developed technique that might well be imitated. I searched the section on permanent habitations (56 pages) to find what use had been made of matters of gabbro, Trias, or fault. One interesting map associates fields and houses with soils of crystalline and calcareous base and properly so. That was all.

The book is one of great industry and scholarship. Moreover, the style is excellent. It will take a deserved place among the classics of its field.

In "L'Oisans au Moyen-Age" Allix refers to the inspiration of what he terms "the celebrated memoir of Albert Demangeon" (Les recherches géographique dans les archives, *Ann. de Géogr.*, Vol. 16, 1907, pp. 193–203). His own study of the Oisans in the Middle Ages is made up of careful piecing of facts from fragmentary archives as old as the twelfth century. The investigation of the historical boundaries of the Lac de St. Laurent is especially interesting for its exposition into the methods of historical research. An ample appendix of source material gives us further insight in the process of the study.

RODERICK PEATTIE

THE JEWISH PROBLEM

SIEGFRIED PASSARGE. **Das Judentum als landschaftskundlich-ethnologisches Problem.** 460 pp.; maps, diagrs., ills., bibliogr., index. J. S. Lehmann, Munich, 1929. M. 15. 9 x 6½ inches.

Professor Passarge approaches the "Jewish Problem" from a new angle, that of the geographer and ethnologist. The Jewish problem is the question of the relation between Jews and gentiles the world over, a relation which Passarge thinks is very bad. "Since the movement of emancipation there have been violent outflarings of hatred" on the part of both Jews and non-Jews. Modern geography and ethnology, by shedding light on the origins and character of the Jews and their institutions, may help remedy a deplorable situation.

In the preface Passarge writes: "Never yet have I composed a scientific work so dispassionately as this, and there can be few books in the writing of which more care has been taken entirely to omit all emotion." A far-reaching comparative study of the physical make-up of the Jews and other folk leads to the conclusion that the former are not a distinctive race and that the Jewish problem is therefore not

to be solved in terms of somatic anthropology. Other Levantines—Armenians, Greeks, Christian Syrians—have "Jewish characteristics," mostly objectionable, in Passarge's opinion. The explanation of these characteristics is to be sought in the history and traditions of the people of the Near East, in whose development geographical factors have played a very large part. To show how this has worked out, Passarge delves deep into lore that is obscure and fascinating. To do justice to this part of the book a critical reviewer would have to be thoroughly versed not only in modern ethnology but in the history of Jewish theology and religious institutions.

Men in the Near East, Passarge writes, may be classified for the most part into two main types, *Sarts*, so called from the oasis dwellers of Turkestan, and *anti-Sarts* (see *Geogr. Rev.*, Vol. 17, 1927, pp. 514–515). The Sarts are the oasis folk, or townsfolk; the anti-Sarts are the rovers of the waste places. Most of the twelve cardinal virtues, political and cultural, which Passarge classifies in a characteristically schematic manner, would seem to reside among the anti-Sarts, whereas the cardinal vices—among them a tendency to form subversive secret societies—are to be found among the Sarts. A study of the Sarts and their manner of living makes clear, Passarge thinks, many of the darker aspects of life in the European ghettos.

"Monotheism is the religion of the oasis Sart. . . . Pure monotheism, however, is by no means the most favorable form of religion for cultural growth. Since it is based predominantly upon the intellectual life and gives only grudging recognition to the life of the emotions, it leads to atheism more rapidly and completely than does any other type of religion—to atheism which is the most inimical to culture of all metaphysical concepts."

Elsewhere Passarge points out that the Germans are well endowed with many of the twelve cardinal virtues and hence should have been admirably adapted to assume world mastery. "A lack of the sense of political reality and an overdeveloped life of the emotions and imagination, however, have thrice brought about their fall . . . the third time when—misled by rabbinical teachings (*verführt durch Rabbinasten*)—the people were blinded to the world of fact by social and humanitarian enthusiasm. . . . Romans once and Britons in modern times possessed the weightiest of the cardinal virtues; possessed them—for recently England, under rabbinical influence, is losing the indispensable feeling for reality."

These quotations may throw some light on Passarge's point of view. We leave it to the reader to judge whether or not they are contradictory and whether or not they exemplify the coldly scientific attitude set up as an ideal. At all events, the book reveals profound learning and bright flashes of originality.

A Mythical Strait

George E. Nunn. **Origin of the Strait of Anian Concept.** 36 pp.; maps. Privately printed, Philadelphia, 1929. $2.00. 9 x 6 inches.

Long before Vitus Bering in 1728 sailed from the Arctic Ocean through the passage that now bears his name, the concept had existed of a "Strait of Anian" separating Asia from North America. The earliest known map on which this strait is named was made by the Venetian Bolognino Zaltieri in 1566, although there is reason to believe that his compatriot, Giacomo Gastaldi, had represented it on a map a few years before. At a later date the concept played an important part in the speculations of seekers for the Northwest Passage, and in modern times it has aroused the interest of many students of the history of geography. It scarcely need be said, however, that the idea was based entirely on theoretical considerations and does not reflect even dimly any knowledge of the actual lay of land and water to the north of Bering Sea.

From the time of Columbus to about 1560 America was generally believed to be

connected with Asia. Thus the "authoritative" globes of Johann Schöner, 1523 and 1533, represented South America as a promontory of Asia and associated it with the land placed by Ptolemy and the Behaim Globe (1492) to the east of the "Sinus Magnus." However, the progress of exploration in the interior of North America and along the east coast of Asia, together with a dawning consciousness that the earth is much larger than Columbus had believed it to be, gradually led to the discarding of the earlier views. Before the "Strait of Anian" as such had made its appearance, Sebastian Cabot, Oviedo, Sir Humphrey Gilbert, and others had become convinced that America and Asia were separate land masses; and it only remained for Gastaldi, or one of his school, to give this doctrine definite form by depicting a narrow passageway between the continents and by giving to this strait the puzzling name of "Anian."

Dr. Nunn, the latest student of this problem, traces the history of theories of the relationship of Asia to America before Gastaldi's time and develops an ingenious hypothesis to show how the name of the province of "Ania" mentioned in Ramusio's text of Marco Polo came to be applied to the strait. The theme is an interesting one, and Dr. Nunn has worked out his thesis with originality and critical acumen. It might be wished, however, that his material were presented more coherently. The following sentence is unfortunately only too typical of the English style of this little book: "By a further confusion this northern *Toloman* and *Anin* or *Ania* were included in the north country outside of *Cathay* so that when *Mangi* and *Cathay* were assigned their new longitudes by Gastaldi on his *Tertia Pars Asiae* 1561, these countries of western *Cathay* found themselves respectively *Anin* (*Ania*) a neighbor to the north of *Mangi*, while other geographers moved *Toloman* (*Tolm*) over into America east of the Strait of Anian" (p. 30).

The Geographical Work of Alfred Hettner

Alfred Hettner. **Die Oberflächenformen des Festlandes: Probleme und Methoden der Morphologie.** 2nd edit. viii and 178 pp.; index. (Geographische Schriften, No. 4.) B. G. Teubner, Leipzig and Berlin, 1928. M. 9.60. 8½ x 6 inches.

Alfred Hettner. **Der Gang der Kultur über die Erde.** 2nd edit. vi and 164 pp.; maps, index. (Geographische Schriften, No. 1.) B. G. Teubner, Leipzig and Berlin, 1929. M. 8. 8½ x 6 inches.

Alfred Hettner. **Englands Weltherrschaft.** 4th edit. vi and 219 pp.; maps, bibliogr., index. B. G. Teubner, Leipzig and Berlin, 1928. M. 9. 8½ x 6 inches.

Alfred Hettner. **Die Geographie: Ihre Geschichte, ihr Wesen, und ihre Methoden.** viii and 463 pp. Ferdinand Hirt, Breslau, 1927. M. 22. 9 x 6½ inches.

Whenever a new volume or a revised edition issues from the pen of Dr. Alfred Hettner, the science of geography once again has been enriched. Hettner has blazed new trails and consolidated ground in many controversial areas of physical and regional geography. Just as the work of Professor Davis, both directly and indirectly, has inspired many in the United States and Europe to engage in the pursuit of geographical knowledge, so Hettner's writings in Europe have brought to bear a telling influence not only upon the younger members of the geography seminars but upon the geographers of his own generation.

An excellent cross section of Professor Hettner's viewpoint is exhibited in the four volumes listed above. These works touch upon a diversity of subjects and impressively reveal the versatility and comprehension of their author. In "The

Surface Forms of the Land" the science of geomorphology is critically analyzed. Hettner seeks to bring consistency to this field of investigation. He emphasizes the importance of a proper coördination between working methods and interpretation. "In all scientific work the first essential is an exact description of what has been observed or is observable. . . . Only then should the explanation or discussion of the causes be introduced; the latter should not be confounded with the description, lest errors be introduced" (p. 13). According to his view, danger lurks in the purely deductive mode of approach; and he argues for the inductive method.

A thorough study of the surface features of the earth is an unconditional requirement for every geographer. To be sure there is some justification in the opposition of geographers to a detailed study of geomorphology for its own sake, but Hettner feels that no geographer can afford to divorce himself from an *understanding* of these forms. They are at the very foundation of an accurate interpretation of the landscape, climate, life itself, economic activities, and even the cultural relations of man. Although morphology and geography have been growing apart in recent years, Hettner expresses the hope that they may again be brought into closer relationship.

In the volume on "The Spread of Civilization over the Earth" Hettner shows consistence in applying his arguments in favor of an understanding of morphology. Following Ritter, he looks upon the earth's surface as man's living quarters and as the environment for the evolution and spread of civilization. "The earth is not the empty stage which it so often is represented to be by the historian" (p. 2). He insists that the geographer must never lose sight of the relationships existing between man's cultural status and the earth upon which he lives. The function of the geographer is to follow the spread of culture over the earth and to interpret it in terms of the natural environment. However, caution must be exercised against drawing sweeping generalizations with respect to the relationship between environment and peoples. Different peoples do not necessarily react in the same manner to a given habitat. Furthermore, the same people in varying cultural stages are likely to show different responses to identical environments. Thus by a searching analysis of given phenomena does Dr. Hettner carefully pick his way through the intricate maze of pitfalls to arrive at conclusions that command the respect of the professional world.

In his clear-cut discussion of "England's Hegemony" the successive adjustments of the British people to their physical environment at various periods in their history are emphasized. Although an advocate of the idea of environmental influences, Hettner shows careful balance when he cites the inherent character of the English people as of the utmost significance in their successful establishment of an unprecedented empire. While he attributes a part of the development of this character to the effect of environment, he also credits much of it to the mixture of peoples.

Summarizing his geographic philosophy in his book upon "The History, Nature, and Methods of Geography," Hettner presents a concise history of geographic thought which merits careful reading by every geographer. He has not only lived through most of the period during which our modern conception of geography has evolved but has been privileged to contribute to it. Born in 1859, the year of the death of both Ritter and von Humboldt, Hettner felt the influence of the works of these founders of modern geography. As a contemporary of von Richthofen and Ratzel, and in his youth of Peschel, he has enjoyed an intimacy with the forward movement of geographic thought that has come to few other men. These experiences become evident as one reads his story of what has taken place in the various divisions of geographic investigation and notes the names of a galaxy of men, many of whom were known personally to Hettner.

Once more Hettner's philosophy of the fundamentals of scientific research impresses itself upon the reader. He insists on banishing the thought of trying to make one's

findings fit certain preconceived ideas; yet, of course, he would not taboo analysis. On the other hand, in a finished geographic study he believes there is some danger lest too detailed an analysis destroy the view as a whole. Therefore synthesis becomes equally important in establishing the geographic picture.

For those who aspire really to advance the science of geography a study of Hettner's methodology and philosophy will yield much profit. His writings abound in considerations of teaching and research methods, as well as in contributions to the content of geography itself. Recently some of the younger among American geographers have sought to introduce new words or new applications of old words to the science. Hettner's suggestion that a terminology must virtually grow out of a phenomenon rather than be imposed on it is one that contains the wisdom of a long and seasoned experience. Those interested in chorology will find in "Die Geographie" especially an enlightening discussion of Hettner's interpretation of the term. He says: "The ultimate objective in the chorological [i. e. the regional] viewpoint is the recognition of the characteristics of countries and localities, growing out of the interrelationships of different natural realms and their various manifestations, and the consideration of the whole earth's surface according to its natural divisions into continents, regions, natural provinces, and localities" (p. 130). This Hettner shows subsequently to be the fundamental concept of geography.

We have noted only a few among hundreds of items which Hettner's works touch upon and which reveal his broad yet thorough acquaintance with the fundamentals of his science. His teachings and writings will stand with those of other illustrious geographers before him, and with those of his contemporaries, as milestones in the progress of geographic thought.

EUGENE VAN CLEEF